

FOLIA LIMNOLOGICA SCANDINAVICA

Edited by

KAJ BERG
Copenhagen

SVEN BJÖRK
Lund

R. RYHÄNEN
Helsinki

No. 14

ECOLOGIC INVESTIGATIONS OF
PHRAGMITES COMMUNIS

STUDIES IN THEORETIC AND
APPLIED LIMNOLOGY

BY

SVEN BJÖRK



LUND 1967

C.W.K. GLEERUP · EINAR MUNKSGAARD · OSLO UNIVERSITY PRESS
LUND COPENHAGEN OSLO

FOLIA LIMNOLOGICA SCANDINAVICA

Edited by

KAJ BERG
Copenhagen

SVEN BJÖRK
Lund

R. RYHÄNEN
Helsinki

No. 14

ECOLOGIC INVESTIGATIONS OF
PHRAGMITES COMMUNIS

STUDIES IN THEORETIC AND
APPLIED LIMNOLOGY

BY

SVEN BJÖRK



LUND 1967

C.W.K. GLEERUP · EINAR MUNKSGAARD · OSLO UNIVERSITY PRESS
LUND COPENHAGEN OSLO

*Printed with contributions from
Statens Naturvetenskapliga Forskningsråd
and Längmanska Kulturfonden.*

*The maps in Figs. 7, 38, 60 and 87 published with permission of Svenska Reproduktions Aktiebolaget. Licence 2467, SRA,
Fack, Vällingby 1.*



Contents

Preface	5
Introduction	8
Material and methods	11
I. Organism sampling and analysis	11
II. Environmental sampling and analysis	22
III. Abbreviations, symbols and definitions	25
ANALYTIC-DESCRIPTIVE PART	
The sampling regions in South Sweden and Zealand	29
I. Biotopes in the Aneboda region	32
General description of the region	32
Lake Fiolen, with biotopes 1, 1 A—B and 2	34
Lake Stråken, with biotopes 3—4	41
Lake Helgasjön, with biotopes 5—6	46
Lake Furen, with biotopes 7 A—D	50
Lake Salen, with biotope 8	55
Lake Trummen, with biotopes 9 A—B	58
Survey of the analyses	61
II. Biotopes in the Veden—Tiken—Ängsjön region	66
General description of the region	66
Lake Rolmsosjön, with biotopes 10—11	68
Lake Linnerydssjön, with biotope 12	73
Lake Veden, with biotope 13	76
Lake Hammaren, with biotope 14	78
Lake Tiken, with biotope 15	81
Lake Ängsjön, with biotopes 16—17	84
Survey of the analyses	89
III. Biotopes in the Orlunden—Norjesund region	95
General description of the region	95
Lake Vitavatten, with biotope 18	96
Lake Vångasjön, with biotopes 19—21	99
Lake Orlunden, with biotopes 22—23	105
The streams Western and Eastern Orlundsån, with biotopes 24—25 ..	109
Norjesund, with biotopes 26, 26 A, 27, 27 A—C, 28, 29 and 29 A	111
Survey of the analyses	124

IV. Biotopes within eutrophic regions in South Sweden and Zealand	130
Lake Jägern, with biotopes 30 and 31 A—D	131
Lake Tåkern, with biotope 32	135
Lake Western Ringsjön, with biotopes 33—34	138
Lake Krankesjön, with biotopes 35—36	143
Lake Björkesåkrasjön, with biotope 37	148
Lake Tystrup Sö, with biotopes 38—39	150
Survey of the analyses	154
V. Biotopes on the coasts of South Sweden and Zealand	159
Orrekulle, with biotope 40	162
Pukavik, with biotopes 41, 41 A and 42	164
Löddesnäs, with biotopes 43—44	170
Bjärred, with biotopes 45 A—C	175
Praestö Fjord, with biotope 46	177
Ängen, with biotope 47	180
Hakenäs, with biotope 48	181
Survey of the analyses	183
SYNTHETIC PART	
Ecology of <i>Phragmites communis</i>	187
I. Variation and variability in <i>Phragmites communis</i>	187
Polyploid levels	188
Pollen quality	190
Pollen size	190
Stomata	195
Seed production	197
Rhizomes and roots	199
Shoot dimensions	201
Panicle frequency and flowering time	206
Shoot density	209
Standing crop and leaf area	210
Expressed sap and press-cake	215
II. Dynamic aspects on the development of <i>Phragmites</i> reed-beds	232
III. Aspects on the rôle of macrophytes in the limnic ecosystem	234
Retrospects and prospects	237
Abstract	239
Literature cited	241

Preface

The reaction of freshwater plants in response to culturally caused changes in the environmental conditions has been studied above all with respect to the phytoplankton. In comparison with the great many planktologic investigations, relatively little attention has been given to the macrophytes, especially to those which have a rhizome and root system deeply penetrating the bottom. In the planktologic studies the environmental analyses are concentrated on the water. The development of the rooted macrophytes is dependent on the conditions in soil, water and air, and thus the analytical part of an ecologic investigation of macrophytes must, *a priori*, be considered to be more complicated than in the case of phytoplankton species studied during their occurrence in a medium of great homogeneity, the water.

In a macrophyte species such as *Phragmites communis* the reaction to auxotrophication has been easily observable. Thus the famous Swedish plant ecologist RUTGER SERNANDER pointed out that "It is not yet determined in what manner the phanerogam vegetation by us is affected in front of sewage outlets etc., but it is conspicuous, how broadleaved *Phragmites*, for example, becomes around the mouth of a sewer

in a lake" (SERNANDER 1912, p. 805, translated from the Swedish).

Especially in an oligotrophic region an auxotrophication has often a striking effect on the quantitative development of *Phragmites* as photographically documented by NAUMANN (1932, Figs. 30—31) in "Grundzüge der regionalen Limnologie".

In 1951 Professor SVEN THUNMARK, head of the Limnological Institute, University of Lund, proposed that I undertake an ecologic investigation of *Phragmites* within the Aneboda region, the classic oligotrophic region of central South Sweden. The program for the investigation was gradually extended to comprise field work in other regions too, field experiments etc. (see Introduction). During my time-consuming investigations Professor THUNMARK has always shown the greatest interest in my studies. From the very start the investigation acquired a regio-limnologic character thanks to the extensive knowledge about the regio-limnologic conditions of South Sweden which Professor THUNMARK possesses. His valuable criticism has often been based on comparisons between different regions. Like all ecologic research work devoted to an organism characterized by great variabil-

ity, occurring in many different types of environment and dependent on different media, this investigation required considerable field and laboratory equipment. However, instruments and other facilities were gradually placed at my disposal by the Limnological Institute.

The main part of the work was carried out in the Limnological Laboratories in Lund and Aneboda, both belonging to the Limnological Institute of the University of Lund.

During my field work in Zealand, Denmark, the Suserup Laboratory at Tystrup Sø was kindly placed at my disposal by Professor KAJ BERG, head of the Freshwater Biological Laboratory in Hilleröd.

When working within the Aneboda region in the winter, Fil. lic. BRUNO BĒRZIŅŠ (now at the Limnological Institute, Lund) as Director of the Fishery Association of South Sweden, gave me the privilege of working in the laboratory of the Association.

Professor KARL-JOHAN KARRMAN and Fil. lic. EINAR BLADH, Institute of Analytical Chemistry, Lund, have given me much valuable advice and help concerning problems with analyses of water etc. Some phosphorus analyses were carried out in the Institute of Analytical Chemistry.

Professor STIG SUNNER, Laboratory of Thermochemistry, Lund, gave me excellent help in starting and carrying out the freezing-point determinations of expressed sap from *Phragmites*.

At the beginning of the checking of the chromosome number of *Phragmites* advice on technical problems was kindly given by Laborator BÖRJE LÖVKVIST, Alnarp, who also encouraged me to pro-

ceed with these investigations, difficult for a limnologist, and furnished me with many thought-provoking ideas.

Laborator NILS MALMER, head of the Department of Plant Ecology, Lund, has shown great interest in my investigation and has offered helpful suggestions and the most valuable criticism.

At congresses and on excursions, e.g., in Roumania 1964, Fil. dr GUNNAR LOHAMMAR has generously given me the advantage of his authoritative and very rich fund of knowledge about freshwater macrophytes.

I have had several inspiring discussions, for example on excursions in Denmark, Finland and Poland, with Dr. SIGURD OLSEN, Laboratory of Radiation Biology, Seattle, USA, and Cand. mag. HANS MATHIESEN, Botanical Institute, Århus, Denmark.

The sampler (a variety of the Digerfeldt sampler) for obtaining undisturbed vertical bottom sections was constructed in close and congenial cooperation with Fil. lic. GUNNAR DIGERFELDT, Department of Quaternary Geology, Lund, who also kindly checked the ocular classifications of the soil samples.

Fil. lic. ULF LETTEVALL, my colleague for many years at the Limnological Institute, has participated in innumerable discussions on ecologic problems and has always been ready to help, particularly with valuable suggestions on figure design.

In the field work commendable assistance has been given by especially Fil. kand. PEHR H. ENCKELL, Fil. kand. LARS EURENIUS, Fil. mag. GUNNAR HILLBOM, Fil. stud. LARS HILLBOM, and Fil. kand. GÖSTA OLSSON. Water level registrations were carried out in Lake Stråken

by Mr. EDVIN JOHANSSON and in Norjesund by Mr. RAGNAR NORDSTEDT.

Many persons have contributed to the painstaking work with biometric analyses and rendered technical assistance of different kinds. Among those I should like to mention especially Assistant GUNNAR ANDERSSON (biometry), Miss GUNNEL BLOM (microtechnique), Mrs. KERSTIN HEROLD-NILSSON (biometry), Assistant CURT JOHANSSON (biometry), Miss RITA JÖNSSON (biometry, microtechnique), Miss INGRID LILJENBERG (typewriting of tables), Miss GUNNEL NILSSON (biometry, microtechnique), Miss KARIN NILSSON (biometry, microtechnique and other laboratory assistance), Mrs. KARIN PALLBO, and Miss INGER STÅHL (biometry, typewriting).

Mr. OLLE NILSSON, instrument maker, Lund University Institute for Hygiene, brilliantly solved technical problems in making first-class special instruments.

The English manuscript has been revised by Mrs. GAIL ÅKERMAN, Alstad.

My wife, Mrs. ANNA-LISA BJÖRK, has always given me encouragement and self-sacrificing and skilful help in many different sections of the investigation. Most of the final drawings of the figures were made by her.

It is my pleasant duty here to express my cordial thanks to all those persons who in many different ways have facilitated my research work and made it possible for me to penetrate some sections of the complex of problems concerning the connection between *Phragmites communis* and its environment.

The financial aid for the field work has been received from the Royal University of Lund, the Royal Physiographic Society of Lund and Fonderna för blekingsk hembygdsforskning. For technical assistance grants have been received from the Royal University of Lund.* The Swedish Natural Science Research Council and Längmanska kulturfonden have supported the printing of this paper.

Introduction

The fact that *Phragmites communis* attracted considerable interest and was utilized before the lakes in the Nordic countries were greatly affected by human activity is shown by the dissertation of LUNDÉN upon this species in 1795 at Åbo Academy, Finland.

HÜRLIMANN (1951) has presented in his dissertation most of the earlier knowledge in biology, ecology etc. about *Phragmites* and as a result of his thorough and diversified investigations decisive progress has been made in *Phragmites* research.

The utilization of *Phragmites* for industrial use (production of cellulose etc.) caused a further intensification in the investigations and *Phragmites* research centers were established at Maliuc in the Roumanian Danube delta (RUDESCU et al. 1965, with a comprehensive bibliography) and at Mikołajki in the Mazurian Lake District, Poland. Plans have also been made to exploit the vast reed-beds around the junction of the Tigris and Euphrates (cf. BJÖRK 1966).

My ecologic investigations on freshwater macrophytes were started in 1951 in lakes within the oligotrophic Aneboda region in central South Sweden. Besides *Phragmites* also *Equisetum fluviale*,

Typha latifolia, *Nuphar luteum* and *Nymphaea alba* were included. However, the main interest was concentrated on *Phragmites*. The primary aim was then to make biometric comparisons concerning *Phragmites* between lakes as intact as possible and lakes auxotrophicated by sewage etc.

In the originally, from a regio-limnological point of view, homogeneous oligotrophic Aneboda region an auxotrophication by sewage results in a marked increase in the dimensions of the *Phragmites* shoots. In order to study the rate, mode and degree of the reaction of the organism in a biotope polluted by sewage, series of field experiments were started in 1957 in lakes within the Aneboda region. Some of these series are still in progress.

During the fifties and early sixties the investigations were successively widened to include biotopes in Småland outside the Aneboda region, in the province of Blekinge, as well as within eutrophic regions in the provinces of Södermanland, Östergötland, and Scania in Sweden and in Zealand, Denmark (Fig. 4).

At an early stage in the investigation it was found that the mode of reaction to similar environmental conditions was — due to differences in the genetic

constitution — often highly different with respect to different *Phragmites* clones.

The great morphologic and dimensional variation in *Phragmites* has caused a confused taxonomic division which needs a thorough revision. The taxonomy was a subject to critical comments by HÜRLIMANN (1951), who also treated the geographic distribution of the genus. The species validity of *Phragmites Karka* Trin. (in tropical and subtropical Asia and in Australia) and *Ph. dioica* Hackel (in Argentina) is considered as dubious and “die beschriebenen Abararten” of *Phragmites communis* are “oft nicht gut abgrenzbar und anscheinend auch nicht konstant” (HÜRLIMANN op. c., p. 14).

According to a few reports about the chromosome number in *Phragmites communis* triploid, tetraploid, heptaploid, and octoploid types have been found. As no determinations at all have been carried out in Sweden, it was necessary to check the chromosome number concerning the investigated clones. This work was started in 1957, but the main part of these investigations was carried out in 1962—1963. Some results including the report of a hexaploid type, have been published (BJÖRK 1963).

In order to test the stability of the morphologic characteristics of some types, cultivation experiments were made in biotopes with other environmental conditions than those prevailing in the biotopes from which the plant material was taken. These field experiments were started in 1958 and are still going on.

Besides the studies on the dimensional variability, standing crop etc. in different combinations of environmental conditions and *Phragmites* clones, analyses of

chemical and physical properties of various parts of shoots and rhizomes were carried out from 1962. The analytical work was concentrated on the sap expressed according to the method recommended by WALTER (e.g., 1931 a, 1931 b, 1951) and others.

Most of the environmental-analytical part of the investigation was concentrated to the years 1963 and 1964.

The opportunity of using samplers, by means of which undisturbed soil sections were obtainable at all water depths of current interest for the investigation, made it possible for the most part to get soil samples from the whole bottom layer which — through the activity of the macrophytes — could play an important rôle in the ecosystem of a lake.

Originally the intention was to analyse soil cores from a series of biotopes at different times of the year in an attempt to follow changes in the concentrations of plant nutrients in the soil which could be caused by the activity of the plants. However, in the investigated biotopes the stratigraphical conditions were mostly so complex that it was very difficult to get comparable samples on the different sampling occasions, i.e., it was difficult to relocate with a tolerable degree of exactitude the same level as sampled on an earlier occasion. Therefore in most cases analyses from only one representative vertical section per biotope are presented.

As for *Phragmites communis* the genotypically induced variation is great at the same time as the range with respect to different environmental factors in the spectrum of biotopes in which this

species occurs is also very great. Therefore, the results from investigations within a restricted area with but few constellations of *Phragmites* types and environmental conditions ought to be treated with caution and their general validity tested against the results from several other constellations.

Thus the guiding principle in my investigation has been first of all to obtain as broad a knowledge as possible about the degree of variability concerning the organism and its environment within the investigation region. On the basis of these studies a program including detail investigations of special problems was successively built up.

In this paper the fundamental in-

vestigations, mainly in South Sweden, of a regio-limnologic character and constituting the necessary first step in the ecologic research program for *Phragmites communis* are treated. Regarding the other sections of the program the reader is referred to the chapter Retrospects and Prospects.

As the analytical work concerning physical and chemical properties of water, soil, and plant material had to be carried out by the author himself, the number of analyses was necessarily restricted and the planned determinations of, e.g., N, S, saccharides (for evaluation of their share in the osmotic potential of the expressed sap), and for the most part also P had to be omitted.

Material and Methods

I. Organism Sampling and Analysis

The organism analysis consisted of biometric analysis of the fresh plant material (including stomata), determination of standing crop, chemical and physical analysis (including determination of dry matter and ash) of expressed sap, press-cakes and whole plant material, determination of pollen size, estimation of pollen quality and determination of chromosome number.

1. Fresh Plant Material

Sampling

All the plant material treated in this paper was sampled from *Phragmites communis* stands with no or insignificant intermingling with other macrophytes.

In order to get comparable biometric data concerning the maximal development of the shoots in different biotopes, samplings were made mainly during the flowering period. From a biologic point of view the flowering period is that phase in the yearly developmental cycle of the shoot which is the easiest to determine with exactitude in different biotopes.

In South Sweden and Zealand, where the material was collected, the flowering of *Phragmites* occurs in August and September. In some constellations of *Phragmites* and biotope types the flowering does not take place until early October or in some years even later. At flowering all leaves of shoots with panicles are developed and in shoots

without panicles the maximal number of leaves is then usually developed. The incompletely developed terminal leaves of the last-mentioned shoots often remain in the rolled-up stage of development for the rest of the autumn. In the flowering period some of the lower leaves of the shoot are dry. However, the main part of these are those small leaves which have lost their photosynthetic capability already in early summer. Thus it can be stated that the *Phragmites* shoot at the flowering period, at least under normal conditions, has reached its maximal degree of development and the dimensions of the different shoot parts have then attained their greatest stability. Under all circumstances the flowering period must be considered to be the most suitable period for collecting *Phragmites* material for biometric analysis in order to make comparisons between different biotopes in which the *Phragmites* clones, due to genetical and environmental conditions, at a fixed date show different stages of development.

For special purposes (cf. below, p. 14 ff.), e.g., for determination of mineral constituents in the shoots during different seasons, sampling was not restricted to August–October, but was, of course, carried out during the whole vegetation period.

Sampling was always performed within areas with shoot size and density as characteristic and homogeneous as possible for the clone and biotope under investigation.

As for the number of sampled shoots and the size of the areas within which shoots were sampled, three different methods were employed.

Sampling method 1. In those cases when the intention was to collect material merely for biometric analysis of shoot qualities, no sample squares were used, but shoots, as a rule shoots with panicles, of characteristic dimensions for the biotope were sampled within a restricted but not exactly fixed area.

Sampling method 2. For biometric analysis of shoot qualities and for approximate quantitative comparisons between different biotopes 16 shoots were taken within each of a number of equal sample squares with a minimum size of 1 m². The basic principle for the distribution of these in a *Phragmites communis* stand was four sample squares with the side length a placed in the corners within a square with the side length $3a$. However, depending on irregularities in the configuration of the stands, the arrangement and number of the sample squares had to be adapted to the local conditions and to the special scope of investigation (e.g., sections perpendicular to lake shores from shallow to deep water, through luxuriant stands just around sewage effluents etc.). As each sample square had to contain at least 16 shoots, the size of the squares was adapted to the shoot density and varied between 1 and 64 m². The sampled shoots were taken as far as possible according to the principle illustrated in Fig. 1. When, for example, the shoot nearest to a spot where a shoot ought to be sampled was broken, damaged by insects etc., the second nearest to the spot was taken instead. The shoots were sampled independently of their position in relation to different rhizome parts (cf. HÜRLIMANN 1951 p. 41 and KAIKKO 1934, p. 13).

Sampling method 3. The third method was used in sampling for biometric analysis of shoot qualities and for determination of standing crop. All shoots within a sample square with a minimum size of 0.5 m² were taken. The number and arrangement of the squares were modified according to local conditions and to the scope of investigation.

The shoots were cut at the bottom surface and placed in paper and plastic bags. The biometric analysis was carried out immediately after the sampling.

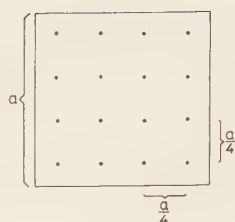


Fig. 1. Distribution of sampled shoots within a square when using sampling method 2.

Biometric Analysis

Shoot density is given as the number of shoots per m².

Shoot length. For shoots with panicle the length denotes the distance between the section surface (at the bottom) to the top of the panicle. For shoots without panicle the length denotes the distance between the section surface to the insertion point of the uppermost completely developed leaf.

Green leaves. Fairly often the terminal part of the leaf dries rather soon after the leaf has become completely developed. Leaves having a green part constituting at least 50 % of the total leaf area were designated "green leaves" in the records. The drying of the leaves proceeds from the base to the top of the shoot. Until and including the flowering period the front proceeds slowly upwards and there is a well-marked limit between totally dry and nearly totally green leaves. Thus only a very small number of leaves designated as green has such a small green area as 50—70 % of the total leaf area. Leaves in the rolled-up stage of development were not included in the number of green leaves. The lowermost leaves of the shoot are triangular, having downwardly decreasing length/breadth ratios. In the biometric analysis a limitation must be made. In order to be designated as a "leaf" (dry or green) the length/breadth ratio was stated to be at least 1.

Leaf length. In some biotopes, especially those situated at seashores, the terminal parts of the leaves are often torn by the wind, and at the flowering period the length is measurable only on the youngest leaves.

Leaf breadth denotes the greatest breadth of the leaf.

Leaf area. In order to determine the

total leaf area per shoot and per biotope unit area as exactly as possible the following method was employed. The method is based on the fact that *Phragmites* leaves with equal lengths and breadths have approximately the same areas.

A great many leaves (about 2350) of all combinations of length and breadth occurring in the investigated biotopes were carefully contoured on paper of a definite quality with an even weight per unit area. The contoured leaves were cut out and weighed on a Mettler analytic balance (type H 5). The weights were plotted on a graph with the leaf lengths on one axis and the breadths on the other.

As the lengths and breadths of the leaves were always registered in pairs in the records from the biometric analyses, the paper weight of the leaves of, for example, one single shoot or of all shoots in a fixed area could easily be calculated. This weight was divided by the mean weight per unit area of the paper and thus the sums of the leaf areas were obtained.

The leaf area is given in dm^2/shoot and in dm^2/m^2 bottom surface.

Stomatal guard-cell length and stomatal density were determined on thin sections cut from epidermis on the abaxial surface of the leaves, in the middle part on either side of the midrib just below the first node mark. The position of the leaf on which sections were cut was carefully noted, i.e., the position (insertion point) of the leaf in relation to the bottom and the number of the leaf counted from below) on the shoot. During the measurement of the length of the guard-cells (magnification $790\times$) and the countings of the number of stomata per unit area (magnification $190\times$) the sections were kept in tap water. Stomatal countings were made along cross sections in intercostal zones with homogeneous distribution of stomata. In the tables with data concerning stomata there is a column giving the product of the area of the investigated leaf and the stomatal density in the intercostal zones at a fixed spot of the leaf. It is here emphasized that this product should not be looked upon as a figure for the total number of stomata on the under-side of the leaf. Provided that the cutting places are compar-

able, it is, however, permissible to make comparisons between different clones and biotopes by means of these products.

Panicle length denotes the distance from the insertion point on the culm of the lowermost branch in the well-delimited flower cluster to the top of the panicle. Sometimes small branches are inserted more or less far below this point. The distance from the insertion of the lowermost small branch to the panicle top was also registered in the biometric records. For determination of panicle weight (cf. below) the panicle was cut off at the first-mentioned branch insertion point.

Culm diameter. This was determined at two places on the shoot, viz., at the first complete internode above the basal cut surface and at the internode surrounded by the sheath of the lowermost green leaf. The diameter was determined in the middle part of the internode after the sheath had been removed.

Other registered shoot qualities: number of dry leaves; number of undeveloped leaves; number of node marks on the leaf; internode length (including the length of the panicle stalk, i.e., the distance from the node at which the uppermost leaf sheath arises to the insertion point of the lowermost branch in the well-delimited flower cluster); number and position of side shoots on the culm; number and position of node roots on the culm.

Fresh weight. In connection with the biometric analysis the plant material was divided into three groups, viz., 1) green leaves, 2) panicles, and 3) rest. Mostly a division was made between shoots with and shoots without panicles. Group 3 thus includes culm (with panicle stalk), sheaths, dry leaves, undeveloped leaves, side shoots, and node roots. The fresh weight for each group was determined. In spite of the fact that the shoots had been kept in cool and moist environment during the biometric analysis, the fresh weight — especially of large shoots — has, due to transpiration (condensation of water on the inside of the plastic bags), probably decreased somewhat during the handling. Therefore, the fresh weights cannot be considered as being quite exact but a little too low.

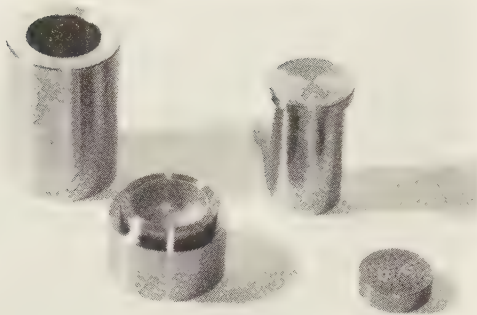


Fig. 2. Press of stainless steel for expression of sap from *Phragmites* material.

2. Expressed Sap, Press-Cakes and Dried Whole Plant Material

a. Expressed Sap

In the main the sampling and expression of sap for determination of the osmotic potential etc. were carried out according to the methods described by WALTER (1928, 1931a, 1931b, 1951) which have come into common use (cf., e.g., OPPENHEIMER 1932, STEINER 1933, 1934, NAVALKAR 1940, TAKADA 1950, 1951, 1954, PISEK & TRANQUILLINI 1951, TAKADA & NAGAI 1953, KURIMOTO et al. 1954, LEHTORANTA 1956, BLUM 1958 and BERNSTEIN 1961, 1963).

Sampling

Leaves, panicles, parts of culms and rhizomes were collected in 300 ml wide-mouth glass bottles with ground-in stoppers. The rhizomes were washed very rapidly with distilled water and immediately dried with absorbent paper before being divided into suitably large parts for the bottles. In order to avoid those parts of the rhizomes in which water from the biotope as well as distilled water might have been absorbed, only the middle sections of dug-up rhizome pieces were collected for analysis. At least one internode and one node were also discarded on each side of a node with a wound after a root.

The sampling was made as rapidly as possible. In the field the bottles were placed in an ice-box and kept there or in a refrigerator until further treatment of the plant material.

At the time of sampling the degree of development of shoots and panicles was noted and the position of collected plant parts in relation to the bottom surface was carefully determined. Whenever it was possible to make a distinction between shoots with and without panicles, separate samples were taken from the different shoot types.

In tables the lowest, the highest and the mean insertion levels are given together with the mean range, i.e., the mean of the distances between the lowest and the highest insertion levels on the shoots. With "upper leaves" is meant the three upper and with "lower leaves" the three lower leaves (in tables).

In connection with the sap expression the weight of the whole plant material was determined.

Sap Expression

As soon as possible after the sampling, the refrigerated plant material was killed by heat treatment. The bottles — tightly covered with heat-resistant plastic — were placed for one hour in a thermostat with a temperature of 100°C. [Extensive experimental investigations concerning the necessity of killing the plant material before expression of sap have been carried out by, e.g., WALTER (1931b), THREN (1934) and BROYER & HOAGLAND (1940)].

Until sap expression the killed plant material — still in the bottles with ground-in stoppers — was stored in deep-frozen condition.

The sap was expressed from the thawed plant samples by means of a hydraulic jack — with a manometer — fixed in a frame of steel beams (Origo Hydraulic Press, mod. HP-10) and a special press of stainless steel (Fig. 2). This consists of a cylinder (inner diameter 50 mm, inner depth 80 mm) with a flat, perforated bottom plate and a tightly fitted piston with flat pressure surface. The plant material samples were placed within press cloths of a loose linen weave with strong threads and put into the press cylinder. The pressure was slowly increased until a pressure of 250 kg/cm² on the press piston surface acting upon the plant material was obtained. The pressing was continued until the pressure decrease from 250 kg/cm²

in 5 minutes did not exceed 25 kg/cm². The expressed sap was collected in a plastic bowl, encased in the separate press foundation below the perforated plate.

In the press cylinder the samples together with the press cloths were arranged so that shearing of the plant material was avoided (cf. BROYER & HOAGLAND 1940, p. 502). The main part of the sap was expressed during the first phase of the pressing, at a pressure of about 50—100 kg/cm². As the different *Phragmites* tissues used for sap expression were fairly hard and rigid, the press-cakes consisted of compressed but untorn parts of shoots and rhizomes.

The expressed clear sap was filtered (Munktell's filtering paper no. 00) and, until analysed, kept in well-stoppered plastic bottles in a refrigerator at about 0°C. Two small thymol crystals were added to each sap sample.

A n a l y s e s

pH-determinations were made by means of a Beckman pH-meter mod. N. In order to save small sap samples, a small combination electrode (Beckman 39142 comb. electrode) was used.

Specific conductivity was determined with a Radiometer conductivity meter type CDM 2d equipped with cells of the types CDC 104 for normal size sap samples with a volume of about 10 ml or more, and CDC 114 for sap samples smaller than 10 ml. The requisite volume for measuring with CDC 114 is 0.6 ml.

The determinations of pH and specific conductivity were made on samples adjusted to 20.0°C in a water-bath.

Colour. In the determination the sap was kept in a glass tube with a diameter of 20 mm. The tube was held against the white mask no. 3 and the sap colour compared with the colour scale in Plate 5 in "Farbenbestimmung in der Biologie" by PACLT (1958).

Sodium and potassium were determined by means of an Eppendorf flame photometer with "gasol"-air flame. In 1962 the determinations were made in the Central Analytical Laboratory of Lund Hospital. In 1963 and 1964 the analyses were made with the same type of instrument in the Limnolo-

gical Institute. The sap samples were evaporated, treated with HNO₃ and HClO₄ for the destruction of organic matter, and again evaporated. The residues were dissolved in diluted HCl. The determinations of sodium and potassium were made after dilution to a highest content of 10 and 8 mg/l respectively of these elements.

Magnesium and calcium were determined titrimetrically with versenate (indicators: Merck indicator buffer tablets 8430 and calcon) after treatment of the samples with HNO₃, HClO₄, and HCl.

Chloride was determined by potentiometric titration with silver nitrate solution using a mercurous sulphate — silver-silver chloride electrode system.

Total iron was (after treatment with the acids) determined colorimetrically with orthophenanthroline after reduction with hydroxylamine hydrochloride. The colour measurements were made with a Klett-Summerson colorimeter (cell length 40 mm).

Total phosphorus. The determinations were made according to ZINZADZE (1935) and KNUTSON (1949) after treatment with acids according to TAMM (1954). Only a few phosphorus determinations were made on expressed sap. A Spectronic 20 colorimeter was used.

Freezing-point determination and calculation of osmotic potential. The determination of the osmotic potential of plant saps used to be made by means of either plasmolytic or cryoscopic methods. The cryoscopic method has the advantage of being accurate and especially suitable for ecologic investigations as the samples of plant material and saps with the observance of certain procedures could be stored for some time without being affected. The advantages of the cryoscopic method for determination of the osmotic potential has been stressed by many authors, e.g., WALTER (1931a, 1931b, 1951, p. 273) STEINER (1939), and BURSTRÖM (1942, p. 3).

The freezing-point determinations were carried out by means of a cryoscope consisting of a Dewar jar, freezing tube (with stirrer) in an air jacket and a Beckmann thermometer divided into 0.01°C. Temperature readings were made with an accuracy of 0.001°C by means of a magnifying glass.

The thermometer was calibrated with deionized water and NaCl solutions with known freezing points (LANDOLT-BÖRNSTEIN 1962, p. 865). Within the reading part of the scale the distances between the calibration points were about 0.3°C . During the calibration the cooling bath was adjusted to 3°C below the freezing points of deionized water and the different NaCl solutions.

During the freezing-point determinations of expressed saps the temperature of the cooling bath was always kept at a temperature of $-6 \pm 0.5^{\circ}\text{C}$ when using a freezing tube of standard size for samples of 11 ml. A preliminary determination of the freezing point was made for every sap sample after a 4°C supercooling of the liquid in the freezing tube which was then placed directly in the cooling bath. The supercooling was terminated by seeding with ice crystals of the liquid under investigation. The crystals were kept in capillaries placed in tubes in a separate cooling bath with a temperature of about -12°C . In the definite freezing-point determinations the freezing tube was placed in the air jacket and the seeding was performed at a supercooling of 0.5°C below the preliminarily determined freezing point. Temperature readings were made at intervals of thirty seconds. Duplicate determinations were made on every sample. Between readings, over night, and other intervals, the thermometer was kept in 0°C distilled water.

The readings were plotted against time. In order to correct the lowering of the freezing point of the solution, which is caused by the increasing concentration of the solution due to ice formation, the true freezing point was calculated as the point of intersection between the tangents of the cooling curve's sections on both sides of the freezing point of the curve. The mean of the two calculated values is used for the estimation of the freezing-point depression. The zeropoint of the thermometer was continually checked through freezing-point determinations on deionized water.

In some few cases the sap samples were smaller than 11 ml. The smallest sap volume on which freezing-point determinations were made was 5 ml. A special freezing tube was used for these determinations. When using this tube the temperature of the cooling bath

was adjusted to be about 0.5°C higher than when using the large one. This was done in order to get freezing curves with about the same slope in the section after the freezing point when using the large as well as the small tube.

On the basis of the determined freezing-point depression (denoted $\Delta T^{\circ}\text{C}$) of a sample of expressed sap, the osmotic potential (LEVITT 1951 a, 1951 b) at 20°C (denoted O_{20}) was calculated according to the tables given by WALTER (1936, pp. 330 and 333).

Water content, dry matter (drying at 105°C) and ash content (ashing at 550°C in an electric furnace) were determined on the expressed sap.

b. Press-Cake

After the expression of the sap the press-cake was weighed and the water content and dry matter determined after drying at 105°C . As the weight of the fresh whole sample was known, the amount of expressible sap per kilogram fresh whole *Phragmites* material could be calculated.

The dried press-cake was ground in a Wiley laboratory mill equipped with a sieve with 40 meshes per inch.

One part of the thoroughly mixed ground sample was used for determination of ash content (ashing at 550°C).

Another part was used for determination of mineral constituents after treatment with HNO_3 , HClO_4 , and HCl (cf. TAMM 1954, p. 14 and MALMER & SJÖRS 1955, p. 49). Concerning the methods for determination of sodium, potassium, calcium, magnesium, and iron see under "Expressed Sap".

On the basis of the water content, dry matter and ash content of expressed sap and press-cake, these qualities could also be calculated for the fresh whole plant sample.

c. Dried Whole Plant Material

Determinations of dry matter (drying at 105°C) and ash content (ashing at 550°C) were carried out on air-dried plant material, cut in pieces. In some cases chemical analyses (see under "Expressed Sap")

were made after grinding and wet combustion of dried whole plant material.

Standing crop is given as dry matter in g/m² at the time of flowering (cf. WESTLAKE 1963, p. 387).

3. Pollen Size and Pollen Quality

a. Pollen Size

As is well known, the size of pollen grains with preserved intine is unstable and varies with the degree of moisture of the intine (cf., e.g. SCHOCH-BODMER 1936). Therefore, before making comparative size measurements of pollen, the intine ought to be removed.

After testing different methods, the acetolysis method (ERDTMAN e.g. 1936, 1943, 1952) was chosen for the preparation of *Phragmites* pollen. Besides being universally used, this method is rapid, easy to carry out and makes it possible to prepare the different samples with satisfactory uniformity. Furthermore, the acetolysis method is the most common one used in pollen analysis. As size determinations on grass pollen are frequently made in pollen analysis, the results of the comparative size measurements concerning *Phragmites communis*, a species with pollen of "wildgrass type", may find some direct applicability in the grass pollen analysis.

In comparison with fresh untreated pollen, the size of acetolysed pollen is somewhat

increased. For comparative biometric analysis of pollen samples of the same plant species this circumstance is negligible, but the preparation method must give exactly reproducible and comparable results. In the case of *Phragmites* this is of special importance as the size differences of pollen between different clones and biotopes are often small.

Among the series of checkings concerning the influence of different moments in the acetolysis method on the size of *Phragmites* pollen grains, the following results seem to be of more common interest, viz., 1) the significance of the duration of the acetolysis, 2) the size-sorting effect of centrifuging, 3) the size changes of acetolysed pollen stored in 50 per cent glycerine, and 4) the effect on the pollen size of dry storage of the pollen samples.

The results of some experiments with acetolysis of different duration are shown in Table 1. Pollen has been acetolysed for 3, 6, 9, and 18 min. In all cases the centrifuge tubes with acetolysis mixture (temp. ca. 20°C) and pollen were placed in a water bath with an initial temperature of 70°C. After 3 min. the temperature of the bath was 85°C and after 6 min. the bath began to boil. Thus, in these experiments the pollen samples (in acetolysis mixture) which in Table 1 are stated to be acetolysed for 9 and 18 min. have been kept in boiling water for 3 and 12 min. respectively.

In agreement with CHRISTENSEN (1946) I have found that the size of pollen grains

Table 1. The dependence of the size of the *Phragmites* pollen on the duration of the acetolysis. n=675 (every series comprises 3×225 measurements). As for symbols see pp. 26—27.

Biotope and year	Duration of acetolysis, minutes	Pollen diameter μm					Pollen volume $\mu\text{l} \times 100$ m
		m	e	s	min	max	
21 Vångasjön 1957	3	28.0	0.07	1.76	21.6	32.4	115
	6	27.5	0.06	1.68	21.6	32.4	110
	9	27.3	0.06	1.60	21.6	31.5	108
24 Gränum 1955	3	27.8	0.05	1.33	21.6	31.5	113
	6	27.5	0.05	1.23	21.6	31.5	110
	9	27.2	0.05	1.22	22.5	31.5	105
27B Norjesund 1956	3	33.7	0.08	2.15	27.0	41.4	202
	6	33.1	0.08	2.03	27.0	41.4	192
	9	32.8	0.07	1.91	27.9	41.4	185
	18	32.3	0.07	1.88	27.0	37.8	178

Table 2. The size-sorting effect of centrifuging on acetolysed *Phragmites* pollen. Pollen from biotope 27B Norjesund, 1956. n=225. As for symbols see pp. 26—27.

Sequence of the measurement series	Surface layer						Bottom layer					
	Pollen diameter, μm					Pollen volume $\mu\text{l} \times 100$	Pollen diameter, μm					Pollen volume $\mu\text{l} \times 100$
	m	e	s	min	max		m	e	s	min	max	
First	33.0	0.13	2.01	27.0	38.7	188	.	.	.	.	.	.
Second	.	.	.	.	.	.	33.7	0.14	2.11	28.8	39.6	202
First	.	.	.	.	.	.	33.9	0.14	2.04	27.9	39.6	206
Second	33.0	0.13	1.93	29.7	38.7	188	.	.	.	.	.	.

decreases with increasing duration of the acetolysis. However, CHRISTENSEN (op.c.) found that size constancy of pollen from *Corylus*, *Alnus*, *Thalictrum*, and *Helianthus* was reached already after a few minutes of acetolysis. No constancy of this kind was established for *Phragmites*, but the pollen size showed successively decreasing size as the time for the acetolysis was increased from 3 to 18 min. The experiments show that the acetolysis time must be of exactly the same length for all samples when comparative size measurements are carried out.

Already after an acetolysis of 3 min. the intine of the *Phragmites* pollen nearly without exception is totally removed. The colour of the grains is pale yellowish after 3 minutes' acetolysis, fairly bright yellow after 6 min., strongly yellowish-brown after 9 min., and brown after 18 min.

For the study of the size-sorting effect of centrifuging, pollen samples of normal size, acetolysed according to the schedule given below (p. 20), have been centrifuged in tapered tubes in order to get as large a vertical distribution of the samples as

possible. As is clearly shown in Table 2, the centrifugation causes a marked size sorting of the pollen grains. Therefore, before making measurements the sample ought to be thoroughly mixed in the centrifuge tube. In the experiments measurements have been made on pollen alternately first from the surface and first from the bottom layers. This has been done in order to compensate the size increase which takes place when pollen is kept in diluted glycerine. When centrifuging acetolysed pollen samples containing pollen grains of different plant species and of different weight and size, the sorting effect is, of course, also of importance for the qualitative composition of the sample in different layers of the tube.

When kept in diluted glycerine or glycerine jelly the size of the pollen grains can increase in spite of the intine being removed. As is shown by the figures presented in Table 3, the size of *Phragmites* pollen increases in 50 % glycerine. (When kept in distilled water the swelling of the pollen is considerably faster.) It is therefore important that measurements are carried out within a

Table 3. Size changes of acetolysed *Phragmites* pollen stored in 50 % glycerine. The pollen sample from biotope 9A Trummen, 1955. n=100. As for symbols see pp. 26—27.

Time of measurement (after acetolysis)	Pollen diameter, μm					Pollen volume $\mu\text{l} \times 100$
	m	e	s	min	max	
45 min.	28.4	0.18	1.80	23.4	32.4	120
7 1/2 hour	28.8	0.19	1.89	24.3	33.3	125
22 hour	29.2	0.22	2.22	21.6	35.1	130
31 hour	29.1	0.18	1.85	24.3	33.3	130
200 hour	29.3	0.19	1.95	25.2	35.1	133
440 hour	30.3	0.22	2.25	25.2	39.6	147

Table 4. The effect on the *Phragmites* pollen size of dry storage of the pollen samples. n=675 (3×225). As for symbols see pp. 26—27.

Biotope and collecting date for pollen sample	Date for measure- ment	Pollen diameter, µm					Pollen volume µl x 100 m
		m	e	s	min	max	
18 Vitavatten 550929	Feb. 1956	26.5	0.05	1.37	20.7	32.4	99
	Jan. 1957	26.5	0.05	1.39	19.8	30.6	99
	Jan. 1958	26.8	0.05	1.23	21.6	30.6	101
	Feb. 1959	26.7	0.05	1.30	21.6	30.6	101
24 Gränum 550929	Feb. 1956	27.4	0.05	1.28	21.6	31.5	108
	Jan. 1957	27.5	0.05	1.28	21.6	31.5	110
	Jan. 1958	27.5	0.05	1.27	23.4	32.4	110
	Feb. 1959	27.4	0.04	1.12	23.4	33.3	108
25 Håkantorps 550930	Mar. 1956	27.7	0.07	1.74	22.5	33.3	113
	Jan. 1957	27.7	0.07	1.75	21.6	34.2	113
	Jan. 1958	27.8	0.07	1.81	18.9	33.3	113
	Mar. 1959	27.8	0.07	1.72	19.8	34.2	113
27B Norjesund 550928	Feb. 1956	32.2	0.08	2.13	24.3	37.8	175
	Jan. 1957	32.2	0.08	2.04	23.4	38.7	175
	Jan. 1958	32.4	0.09	2.25	22.5	38.7	178
42 Pukavik 550930	Mar. 1956	29.5	0.08	2.17	22.5	37.8	136
	Jan. 1957	29.4	0.08	2.02	21.6	39.6	133
	Jan. 1958	29.4	0.08	1.97	24.3	36.0	133
	Mar. 1959	29.2	0.08	1.95	23.4	39.6	130
18 Vitavatten 560909	Dec. 1956	27.6	0.07	1.85	18.9	35.1	113
	Nov. 1957	27.5	0.07	1.71	20.7	35.1	110
	Feb. 1959	27.7	0.07	1.81	20.7	33.3	113
24 Gränum 560909	Dec. 1956	29.0	0.07	1.83	22.5	36.9	128
	Dec. 1957	29.2	0.07	1.84	20.7	36.0	130
	Mar. 1959	29.3	0.07	1.88	21.6	36.9	133
25 Håkantorps 560910	Dec. 1956	29.2	0.08	2.00	23.4	36.0	130
	Dec. 1957	29.2	0.08	2.01	23.4	36.0	130
	Mar. 1959	29.2	0.08	2.05	22.5	36.0	130
27B Norjesund 560908	Dec. 1956	33.1	0.08	2.15	26.1	41.4	192
	Dec. 1957	33.1	0.08	2.03	27.0	40.5	192
	Mar. 1959	33.1	0.08	2.18	26.1	44.1	192
42 Pukavik 560910	Dec. 1956	30.1	0.10	2.52	23.4	38.7	144
	Dec. 1957	30.0	0.10	2.60	21.6	41.4	141
	Mar. 1959	30.2	0.10	2.54	21.6	39.6	144

fixed time after the acetolysis. Concerning the series of pollen size determinations presented in this paper the measurements (n=225) of a sample usually have been completed in 60 min. after the acetolysis and in no case has the time exceeded 100 min.

Since the start of my *Phragmites* pollen measurements silicone oil has been introduced by ANDERSEN (1960) as a better mounting medium for pollen grains. However, for

making size comparisons between the old and young pollen samples in this investigation, the same treatment procedure was necessarily followed with all samples.

Control series for determination of the influence of dry storage of the *Phragmites* pollen samples on the pollen sizes are given in Table 4 with respect to samples of both small and large pollen grains from *Phragmites* clones of different genetic constitution

and from highly different biotopes within the Orlunden—Norjesund and Pukavik regions. The figures indicate that no noteworthy size changes of the air-dried pollen have taken place during the storage time in question here.

The preliminary control experiments concerning the suitability of using the acetolysis method for comparative size determinations of *Phragmites* pollen have clearly shown that all moments in the preparation ought to be made with extreme exactitude and uniformity in all samples. The following preparation scheme has been practised.

The air-dried flowering *Phragmites* panicles were shaken over a glazed plate. The sample of stamina and pollen was thoroughly mixed (cf. p. 192) and stored in stoppered glass tubes.

In a cast Corda centrifuge tube of glass a subsample of pollen and stamina making a 2 mm layer was taken. The acetolysis mixture was made by adding 0.5 ml concentrated sulphuric acid (p.a.) to 4.5 ml acetic anhydride (p.a.). During these preparations water was warmed in a 100 ml beaker with some glass wool on the bottom.

At a water temperature of 65°C the acetolysis mixture was put into the centrifuge tube, and at a water temperature of 70°C the tube with pollen and acetolysis mixture was placed in the beaker. The water level was then about 3 mm above the level of the mixture in the tube. During the continued heating the mixture was stirred now and then. When the water began to boil the tube was immediately centrifuged for 60 sec., whereupon the acetolysis mixture was decanted. The acetolysis time, i.e., the time the tube was in the water bath, was 6 min.

The pollen was treated with 5 ml acetic acid (stirring with glass rod). The decanting of the acetolysis mixture, the adding of acetic acid and the stirring was carried out in 60 ± 5 sec. After centrifuging for 60 sec. the acetic acid was decanted.

The pollen was washed with distilled water (the tube shaken 30 times). The time for decanting the acetic acid, adding of water and shaking was 50 ± 5 sec. The water was decanted after centrifuging for 60 sec.

5 ml diluted glycerine (glycerine and distilled water 1 : 1) were added. Decantation

of water and addition of diluted glycerine were carried out in 60 ± 5 sec. After stirring the pollen material was kept for 10 min. in the diluted glycerine, which then was decanted after 60 seconds' centrifugation.

The pollen-glycerine sediment was thoroughly mixed with a small pipette and a small portion was placed on a slide. The amount of pollen-glycerine mixture was adjusted to be enough to cover the whole surface under a 24 by 32 mm cover glass. Diluted glycerine was neither added nor removed from the edges of the cover glass. With this method there was no evidence of any size-dependent sorting of the pollen grains in different parts of the preparations (cf. WENNER 1948, pp. 107—108). Nor were the pollen grains flattened out by the pressure of the cover glass (cf. SCHOCH-BODMER 1938, p. 75).

The greatest outer diameter of the exine was determined (oil immersion; distance between ocular lines 0.9 or 0.7 μ m) on all grains with intact exine along field-of-view lines parallel to the longer sides of the cover glass. The distance between the lines was adjusted to the density of pollen grains in the preparation in order to get the lines uniformly distributed over the whole preparation. In each preparation the sizes of 225 pollen grains were determined. In certain control experiments 3 times 225 pollen grains were measured (225 pollen grains from each of three separately acetolysed subsamples). Pollen grains of abnormal shape (e.g. long grains, grains with more than one pore etc.) were avoided.

As the shape of the *Phragmites* pollen normally is sphaeroidal, the approximate volume was easily calculated.

b. Pollen Quality

At the time of flowering samples of fresh (not damaged by rain etc.) pollen were collected in glass tubes with aceto-carmine-glycerine. The estimation of the percentage of apparently morphologically good pollen was made within a month after the sampling. The percentage figures obtained with this method are given with 1 % interval.

Samples of air-dried pollen, collected at the time of flowering, were treated with

lactophenol-cotton blue. The percentage figures are in this case given with 5 % interval.

The figures are based on countings of ca. 1000 pollen grains. As a rule estimations of the pollen quality were made on samples from more than one year from each biotope. The presented figures are the highest found for the biotope in question.

Note. In this investigation it was not possible to make the pollen quality estimations on samples from panicles which had been protected by different measures against moisture during the flowering period. The figures for the percentage of apparently morphologically good pollen are based on countings in samples from panicles which have not been damaged by rain from the onset of flowering. However, as several of the investigated clones did not flower until fairly late in the autumn, when the occurrence of mist is rather common, it is not totally excluded that condensed water could have caused damages to the pollen in parts of the stamina. Though all samples with evident or suspected damages of this kind were, of course, discarded, there remains some degree of uncertainty. In some cases damages perhaps might have caused slightly too low percentage figures. Broadly speaking, the *Phragmites* pollen is, according to my experience, rather often destroyed by water damage, at least in lately flowering clones.

4. Seed Setting

Panicles were collected in late autumn and winter. By means of a preparation microscope the panicles were examined and caryopses as well as sclerotia of *Claviceps* were gathered. According to an ocular estimate the caryopses were divided into: 1) well-developed (apparently morphologically good) and 2) undeveloped.

As the analyses of the seed setting by means of this method are very time-consuming, panicles from but few biotopes were examined.

In this connection the reader is also referred to the investigations concerning seed setting by means of the convenient X-ray photography method carried out by GUSTAFSSON & SIMAK (1963).

5. Chromosome Number

Root tips were fixed in chrome-acetic-formalin. As the number of chromosomes in the metaphase plates was fairly seldom countable after fixation in the field of untreated roots, it was necessary to cool these before fixation. At sampling during the spring and summer rhizomes were cooled in the field with ice in well-isolated boxes or the rhizomes were submerged in a tank with water of about 0°C. Furthermore plant parts were sampled at all seasons for cultivation in the laboratory in order to get young roots. The best root development was obtained when cleaned rhizome parts and basal parts of shoots were kept moist in darkness in plastic bags at room temperature. The rhizomes etc. were cooled in a refrigerator in a tank with water of about 0°C. Small stem and rhizome parts were cooled without being put into water but were laid directly in their plastic envelopes in the refrigerator.

The fixed root tips were embedded in paraffin and sectioned. The section thickness was 10 µm. After paraffin-removal and tanning in 1 % chromic acid, the sections were stained in 1 % crystal violet, treated in iodine-potassium iodine solution, alcohol and xylol and mounted in "Permunt".

In the determination of the chromosome number drawings were made and microphotographs were taken from metaphase plates. Optic and photographic equipment: objective Leitz Pl Apo Öl 100/1.32; eyepiece Leitz GF 25×; Zeiss drawing apparatus with polarization filter; Leitz Mikas and Leica.

6. Nomenclature and Grouping of Aquatic Vascular Plants

The nomenclature of the vascular plants is according to HYLANDER (1955).

In grouping the aquatic plant species with respect to their relation to air, water and bottom as well as with respect to their different shoot types, the author follows the scheme given by THUNMARK (1952). This scheme includes the following primary and secondary groups:

- | | |
|------------------|----------------|
| A. Hyperhydrites | C. Hyphydrites |
| 1. Graminids | 1. Riccids |
| 2. Herbids | 2. Elodeids |
| | 3. Isoetids |
| B. Ephydrites | 4. Muscids |
| 1. Spirodelids | |
| 2. Nymphaeids | |

II. Environmental Sampling and Analysis

The environmental investigations comprised analyses of water (surface and interstitial) and soil, as well as some observations on air and weather conditions.

1. Water

Sampling

For analysis of dissolved oxygen samples were taken in Winkler bottles with a volume of about 125 ml. Samples for analysis of phosphate phosphorus were taken in glass bottles with ground-in stoppers. For other analyses water samples were taken in 1 liter plastic bottles.

Samples were taken of surface as well as of interstitial water in the *Phragmites* biotopes. In lakes sampling was often performed pelagically too.

The quality of interstitial water was investigated by MORTIMER (1942) and the great importance of the interstitial water for limnologic conditions in lakes was recently clearly pointed out by OHLE (1964, 1965). As for the distribution of mineral constituents between the soil and water phases in peat the investigations by MALMER (1962 b) are also of great interest in this connection.

The difficulties in getting interstitial water vary with the type of soil from which it is to be obtained. In the investigation in question here the following methods were tried.

In temporarily emerged *Phragmites* biotopes samples of interstitial water from the superficial soil layers were taken in dug pits.

In submerged biotopes as well as from deeper soil layers interstitial water was obtained from soil samples taken by means of different types of stainless steel samplers (described below, pp. 23—24). From the soil

sample the interstitial water was extracted by suction. The sample was placed in a 125 ml Jena glass funnel with sinter-glass plate 17G2 and filtering paper Munktell OOM. The funnel was inserted in a vacuum flask connected with a Pfeiffer suction pump type 1900. The suction time was made as short as possible in order to avoid evaporation. The suction was immediately stopped when the soil had lost so much water that air was able to pass through the sample.

From some types of sediments, e.g., clay gyttja, it was very difficult to obtain interstitial water in this way. After a rapid freezing of the samples it was, however, after thawing, easy to get water by suction also from these soils. For comparative purposes water from some vertical soil sections was suctioned from unfrozen as well as from frozen samples (cf. pp. 38—39).

Analyses (see also "Expressed Sap")

Temperature measurements were carried out at the sampling, either with a mercury thermometer or with an electronic thermometer (cf. the soil analyses).

Secchi disc transparency was determined with a white disc, 25 cm in diameter.

Colour was determined on filtered samples with a Hellige Aqua Tester equipped with colour discs having glass standards with intervals of 5 mg Pt per liter.

Potassium permanganate consumption was determined on acidified samples after boiling for 30 min. in water bath.

Dissolved oxygen was determined according to WINKLER with bromination according to ALSTERBERG (1926). No corrections of the obtained values were made.

Specific conductivity. Measurements were made as soon as possible after the sampling and always on the same day as the samples were taken. Equipment: Cambridge Conductivity Bridge and Radiometer Conductivity Meter type CDM 2d, both equipped with platinized electrodes. In accordance with, e.g., SJÖRS (1946 p. 83, 1952 p. 246 ff.) and MALMER (1962a p. 186) the values were reduced by subtracting the conductivity of the hydrogen ions. Concerning

measurements made in 1963—1966, the temperature of the samples was adjusted to 20.0°C before the determinations. Earlier determinations were often made at other temperatures. In calculating the conductivity of these samples to 20.0°C the correcting factors in DEUTSCHE EINHEITSVERFAHREN (3rd ed., C 8, p. 3) were used. The specific conductivity, κ_{20} , is given as $\mu\text{S} \cdot \text{cm}^{-1}$ or $\text{mS} \cdot \text{cm}^{-1}$. However, in the text and tables the abbreviations μS and mS are used.

pH-determinations were made potentiometrically, at the same time as the conductivity measurements. Equipment: Beckman pH-meter mod. N supplied with either reference electrode 4970 and glass electrode 41263 or combination electrode 39142.

Sodium and potassium. Filtered samples were evaporated to dryness and treated with HNO_3 , HClO_4 , and HCl . Determinations were carried out with an Eppendorf flame photometer with "gasol"-air flame.

Calcium and magnesium. The samples were pretreated in the same way as for determination of Na and K. Ca and Mg determinations were made titrimetrically with versenate.

Iron. Determinations of total iron were made colorimetrically with orthophenanthroline after the water samples had been treated with HNO_3 , HClO_4 , and HCl .

Chloride was up to and including 1962 determined titrimetrically with silver nitrate and potassium chromate. The values were corrected according to MAUCHA (1932). In 1963—1966 the titrations with silver nitrate were made potentiometrically.

Alkalinity. Determinations were made titrimetrically according to BERGER after KARLGREN (1961) with hydrochloric acid in a glass funnel with a sinter-glass plate, bubbled through with N_2 -gas.

Phosphorus. Total phosphorus was determined according to ZINZADZE (1935), KNUTSON (1949), and TAMM (1954). When total phosphorus was determined at the same time as phosphate phosphorus the determinations were made (at the Institute of Analytical Chemistry, Lund University) according to PROCTOR & HOOD (1954).

Freezing-point determination and calculation of osmotic potential. See under "Expressed Sap".

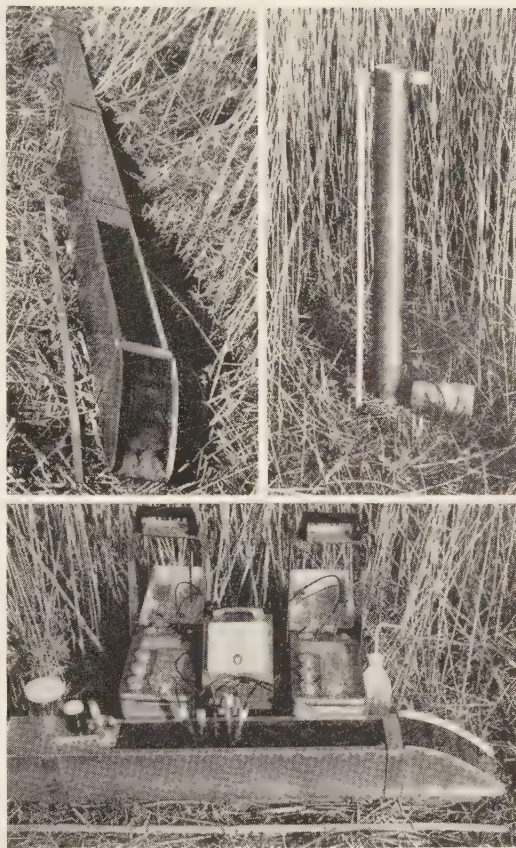


Fig. 3. Top left: The Digerfeldt sampler. Top right: Steel tube for sampling in hard minerogenic soils. Bottom: Measuring of temperature, pH and redox potential.

2. Soil

Sampling

In soft bottoms cores were taken by means of a sampler constructed for this special purpose after a prototype designed by Fil. lic. GUNNAR DIGERFELDT, Department of Quaternary Geology, Lund University. The Digerfeldt sampler was originally made in order to get sediment samples large enough for macrofossil analysis. The latest type used for geological purposes is recently described by DIGERFELDT (1966). The somewhat simpler sampler used by the author consists of a stainless steel tube with a square cross area of 1.2 dm^2 and a length of 1.5 m (Fig. 3). Three sides are fixed, while the forth is movable in grooves along the edges

of the adjacent sides, which are connected by thin bars at the ends and in the middle part. The lower edges of all sides as well as of the bars are sharp-edged to cut off plant roots, rhizomes etc. In sampling the fourth side is not put in until the other part of the sampler is pressed down into the bottom. The fourth side is then pressed down in the track cut up by the sharp-edged lower and middle bars mentioned above. The lowermost part of the fourth side consists of thinner and more flexible steel plate than the rest of the sampler. In pressing down, this part is conducted by grooves obliquely down across the lowermost part of the adjacent sides in such a way that the tube is closed at the lower end. When sampling was performed in bottom areas covered by up to 2 m water the sampler parts were handled with rods from the surface.

After the filled sampler had been drawn up, the fourth side was successively retracted as the temperature was determined from the lower end of the core upwards. Volumetric soil samples for the analyses mentioned below were taken in 30 ml glass jars with plastic snap covers. Three different samples, each with a volume of 25 ml, were taken, viz., one for weight determinations, one for extraction with acetic acid and one for extraction with ammonium acetate. The distance between successive sampling points in the core was, of course, determined by the stratigraphical conditions.

In hard minerogenic soils vertical sections were obtained by means of a steel tube with circular cross section area (Fig. 3). The lower end of the tube was somewhat star-like as the tube edge at some points was bent inwards, thus forming small hooks. The tube was forced down with a sledge. Before drawing up the sampler, the upper opening was closed with a rubber-coated stopper, and the tube was turned in order to loosen the core from the underlying soil and to allow the small hooks to grab the core and prevent it from slipping off the tube.

Analyses

The soil classification was made according to TROELS-SMITH (1955), mostly from ocular determinations. In some cases laboratory analyses were made concerning

minerogenic soils (sieving and pipette method). The symbols in the diagrams of the soil sections are also in the main according to TROELS-SMITH (op. c.). However, as the soils in most cases were ocularly classified, it was not possible to state the proportions of the different soil components with the exactness proposed in the TROELS-SMITH system but they are schematically illustrated in the diagrams of the vertical soil sections.

Temperature measurements were made at the sampling, either with a mercury thermometer or with an electronic thermometer (Tri-R Instruments) with a thermistor as the temperature sensitive device. In both cases the accuracy was $\pm 0.1^\circ\text{C}$. When using the Digerfeldt sampler the temperature was measured directly in the center of the core within a few minutes after the sampler had been drawn up (Fig. 3).

pH-determinations were made immediately after the soil sampler was drawn up. The electrodes were inserted either directly in the soil core (Fig. 3) or in a sample from this. For the equipment see under "Water".

Redox potential determinations were made at the same time as pH was determined. Equipment: Beckman pH-meter mod. N supplied with platinum electrode 39271 and reference electrode 41236. In the measurements the electrodes were inserted in the soil either directly in the core (Fig. 3) or in a sample from this. The values are given in mV at the actual pH and denoted E_h . It has been shown by HAYES et al. (1958) that the presence of H_2S causes a voltage drop. In several *Phragmites* biotopes there was a rich formation of H_2S and probably therefor very low E_h values were obtained. The limited accuracy of the measurements makes it necessary to make also relative comparisons with reservations.

Weights. Determinations were made concerning the weight of whole soil (g/l) and of the dry matter content (g/l fresh whole soil) as well as concerning the loss on ignition (% of dry matter).

Extractable cations. Extractions were made with 1 N acetic acid and 1 N ammonium acetate according to BROWN's method (BROWN 1943), which in Sweden has been used by plant ecologists, cf. SJÖRS

(1954, 1961), MALMER & SJÖRS (1955), MALMER (1958, 1962a, 1962b), and PERSSON (1962, 1964). Detailed descriptions of the method are found in these papers. From the measured changes in pH in the extractants after extraction of the soil samples (standard volume 25 ml whole soil), the amounts of extractable metallic cations and extractable hydrogen ions were estimated and the percentage of neutralization was calculated (cf. SJÖRS 1961). Equipment: Griffin flask shaker, Metrohm Titriskop E 366 with combination electrode Ea 121.

Sodium, potassium, calcium, magnesium, total phosphorus and total iron. The acetic acid and ammonium acetate extracts were evaporated to dryness and treated with HNO_3 , HClO_4 , and HCl . Determinations were made as with water samples. As for the ammonium acetate extracts only sodium and potassium were as a rule determined.

Notes. 1). Rapid changes in the redox conditions sometimes take place in soil samples when they come in contact with the air. The aim has been to try to avoid, as far as possible, changes of this kind. The sampling has been made as rapidly as possible and samples in air-tight jars have been kept in ice-boxes in the field and then in a refrigerator until analysed. In spite of this the following changes have been observed in some gyttja samples (e.g., from Norjesund, where the clay gyttja has a strong H_2S odor): changes (often within a few minutes) of the colour of the sample surface in contact with the air; a rise in the redox potential; a drop in pH. Notes on observed changes in the soil colour are given in connection with the descriptions of the environmental conditions in some of the biotopes.

2). When analysing the chemically often very complex soil extracts the analysis was sometimes disturbed, mainly by either very high amounts of iron or of calcium. Thus, the calcium content in extracts from some of the gyttja (especially the *Nostoc* gyttja) layers in biotope 2 Fiolen, among other things extremely rich in iron, could not be determined by means of the usual titrimetric method.

3. Air and Weather Conditions

Air temperature and relative humidity were determined at the sampling of panicles, leaves and stem parts for expression of sap. The determinations were made with a mercury thermometer and a Lambrecht hair hygrometer just where the samples were taken. As for rhizomes the conditions at the lower leaves are given. During the measurements the instruments were shaded. Weather conditions were always noted in all kinds of sampling. Wind velocities were estimated according to the Beaufort scale.

III. Abbreviations, Symbols and Definitions

Abbreviations and symbols used in this paper are listed on pp. 26—27. As far as possible the abbreviations and symbols given in *STYLE MANUAL FOR BIOLOGICAL JOURNALS* as well as others in common use are utilized (cf. SKRIVREGLER published by Tekniska Nomenklaturcentralen). However, for practical purposes some special ones must be formed for this paper.

Auxotrophication. The term is according to THUNMARK (1948, pp. 32—33) used instead of the inappropriate "eutrophication". The definition of the term "auxotrophication" is here cited from LILLIEROTH (1950, p. 280), who gives the following translation from THUNMARK's original Swedish version: By auxotrophication is meant "that condition of things when the nutritional state in a body of water such as for instance a lake is improved as a result of an extra supply of nutritious materials or of a mobilization of such materials as are already present in it but previously unutilized, or of a combination of these two circumstances".

Biotope is here used with the conditions in the *Phragmites* reed-beds as a starting point. A biotope is "a place of life; the totality of the environmental conditions under which a biocoenose exists" ("Lebensstätte, Summe der Umweltbedingungen, unter denen eine Biozönose lebt", RUTTNER 1963). For practical purposes the biotopes are numbered and the same numbers are kept during the whole period of investigation in spite

of the fact that marked changes in the environmental and organism conditions have taken place in some of the investigated areas.

Whole soil is the designation for fresh soil containing solid matter and interstitial water in original proportions.

Whole plant material is the designation for fresh plant material containing solid matter and expressable sap in original proportions.

Abbreviations and Symbols

A	ash
A 1, A 2, A 3	ash of whole plant material for sap expression (A 1), of press-cake (A 2), and of expressed sap (A 3)
Alk	alkalinity, given in $\mu\text{eq/l}$ or meq/l
AmAc	ammonium acetate
AW	ash weight
BS	broken shoot
Col	water colour, given in mg Pt/l
(D)	estimation of the percentage of apparently morphologically good pollen made on dried pollen after treatment with lactophenol-cotton blue
Date	is mostly given with 6 figures in the order year, month, day as in the following example: May 10, 1959=590510
DM	dry matter (as for soil given in gram per liter whole soil)
DM 1, DM 2, DM 3	cf. A 1 etc.
DS	dry shoot
e	standard error
E_h	redox potential, given in mV at the actual pH
ES	expressable sap, given in ml per kg FW
(F)	estimation of the percentage of apparently morphologically good pollen made on fresh pollen after treatment with aceto-carmin-glycerine
FW	weight of fresh plant material
h	hour
H^+	extractable hydrogen ions, given in meq/l whole soil
HAc	acetic acid
IL	ignition loss, given in % of DM
IW	interstitial water
IWP	interstitial water sampled in a dug pit
IWS	interstitial water obtained by suction of whole soil samples
K ^a	K extractable with 1 N ammonium acetate, given in mmol/l whole soil
K ^b	K extractable with 1 N acetic acid, given in mmol/l whole soil
m	arithmetic mean
Met	sum of extractable metallic cations, given in meq/l whole soil
n	number of observations

Na _a	Na extractable with 1 N ammonium acetate, given in mmol/l whole soil
Na _b	Na extractable with 1 N acetic acid, given in mmol/l whole soil
NPC	neutralization percentage
O ₂₀	osmotic potential, given in atm at 20°C
(O ₂) _s	oxygen saturation of the water in % at the actual temperature
PS	shoot with panicle
Rh	relative humidity
s	standard deviation
Sp.cond.	specific conductivity, given in μS or mS
SW	surface water
Tr	Secchi disc transparency, given in cm
W	water
W 1, W 2, W 3	cf. A 1 etc.
WPS	shoot without panicle
WWS	weight of whole soil, given in gram per liter
ΔT	freezing-point depression, given in °C
θ	temperature, given in °C
μg	microgram=10 ⁻⁶ g
μl	microliter=10 ⁻⁶ l
μm	micrometer=10 ⁻⁶ m
.	not analysed
—	quantitatively undeterminable with the method used (in tables)

Soil symbols

	humic matter		clay, mineral particles < 0.002 mm
	roots and rhizomes of <i>Phragmites</i>		silt, mineral particles 0.06—0.002 mm
	coarse <i>Phragmites</i> detritus; stem parts, dry leaves etc.		fine sand, mineral particles 0.6—0.06 mm
	drift material		coarse sand, mineral particles 2.0—0.6 mm
	gyttja of fine or coarse detritus		gravel, mineral particles 20—2 mm
	moraine		stones, 200—20 mm

Soil analyses

θ	E _h	pH	WWS	DM	IL	NPC	H ⁺	Met	Na _a	Na _b	K _a	K _b	Mg	Ca	Fe	P
See list of abbreviations									mmol/l whole soil. As for Na and K see also list of abbreviations							

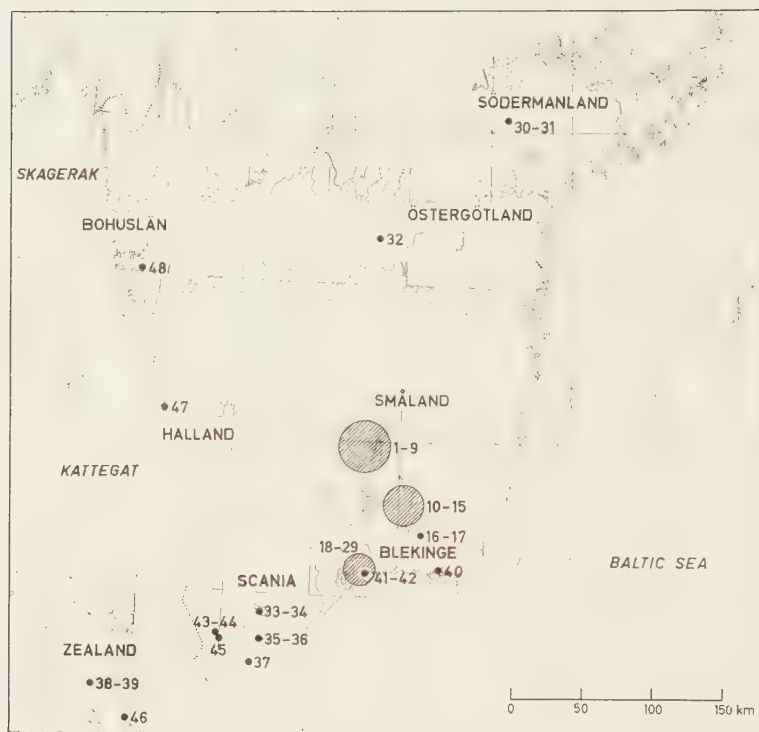


Fig. 4. The geographic location of the investigated biotopes. The hatched circles indicate the Aneboda region (biotopes 1—9), the northern part of the Veden—Tiken—Ängsjön region (biotopes 10—15) and the Orlunden—Norjesund region (biotopes 18—29). Compare also the biotope list in the table of contents, the text on the opposite page and the detail maps in Figs. 7, 38, 60 and 87.

ANALYTIC – DESCRIPTIVE PART

The Sampling Regions in South Sweden and Zealand

The geographic location of the investigated biotopes is shown in Fig. 4. They are arranged in five groups, viz.:

- I. Biotopes in the Aneboda region (no. 1—9).
- II. Biotopes in the Veden-Tiken-Ängsjön region (no. 10—17).
- III. Biotopes in the Orlunden-Norjesund region (no. 18—29).
- IV. Biotopes within eutrophic regions in South Sweden and Zealand (no. 30—39).
- V. Biotopes on the coasts of South Sweden and Zealand (no. 40—48).

In Figs. 5 A—I and 6 A—I some characteristic features of importance for giving an idea of the general physiographic conditions of the regions are presented.

In the general descriptions belonging to each of the biotope groups I—V there is more detailed information about the conditions prevailing in the different regions. See also *ATLAS ÖVER SVERIGE*.

As for Zealand, which is not included in the maps in Figs. 5—6, there is Cretaceous and Tertiary bedrock. The loose earth layers are to a large extent calcareous moraine clays. With respect to climatic and meteorologic conditions there are but small differences between the southernmost part of Scania and Zealand (cf. *DANMARKS KLIMA* 1933, *ALMBORN* 1948). For other physiographic conditions see the descriptions given in connection with the Zealandian biotopes 38—39 Tystrup Sö and 46 Praestö Fjord.



Fig. 5. Physiographic characteristics of South Sweden. A. Altitudes. 1. < 100 m. 2. 100–200 m. 3. 200–300 m. 4. > 300 m a.s.l. (From BEHRENS 1960). B. Main river systems. C. Rocks: 1. Cretaceous rocks. 2. Triassic and Jurassic rocks. 3. Cambro-Silurian rocks. 4–5. Algonkian rocks. 6–11. Archaean rocks, from which 8–9 are granites and 10–11 gneisses. (From MAGNUSSON in SERNANDER 1955). D. Calcareous rocks and soils: 1. Rocks rich in lime. 2. Soils rich in lime. 3. Transport direction of disintegrated rocks rich in lime. E. Highest shore line (present elevation in m): 1. Area which has not been inundated by sea or ice-dammed lakes. 2. Area below the highest shore line. 3. Maximum extension of ice-dammed lakes. (From LUNDEGÅRDH et al. 1964.) F. Distribution of lake sediments: 1. Sediments rich in iron. 2. Sediments rich in lime. (Schematized from NAUMANN 1932 and THUNMARK 1937.) G. Mean annual temperature. H. Mean temperature in January. I. Mean temperature in July. (D and G–I from ATLAS ÖVER SVERIGE.)

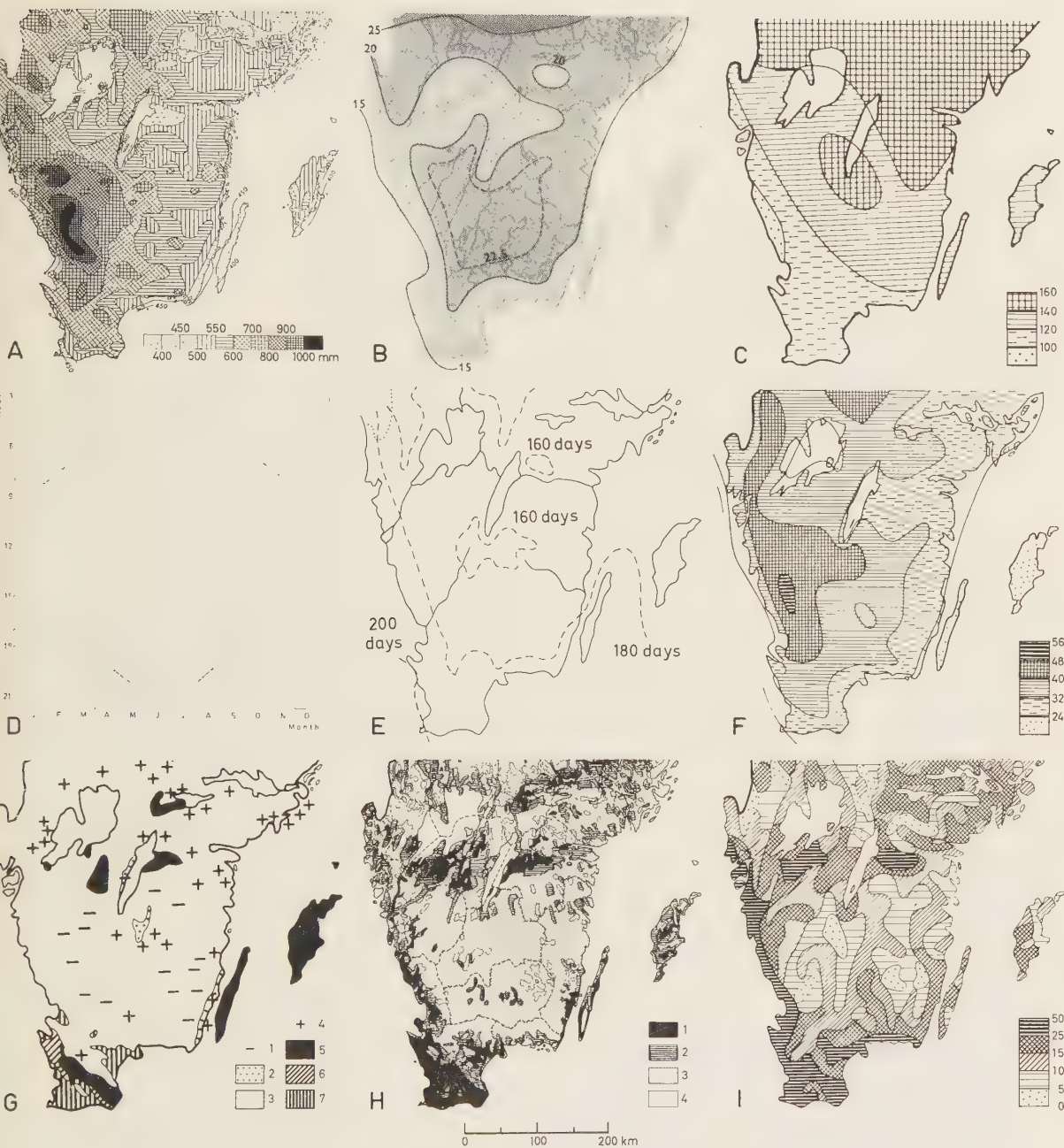


Fig. 6. Cont. from Fig. 5. A. Mean annual precipitation. (From SERNANDER 1955.) B. Precipitation of snow in per cent of total annual precipitation. C. Duration in days of ice cover on lakes. (From ÅNGSTRÖM 1958.) D. Day length during the year in Katrineholm (solid line) and Lund (broken line). E. Duration of vegetation period, i.e., number of days with mean temperature $> +6^{\circ}\text{C}$. (From SJÖRS 1965.) F. Humidity during the period with daily mean temperature $> +3^{\circ}\text{C}$. The figures for the degree of humidity for this period, M_v , calculated according to the formula $M_v = \frac{365}{n_v} \cdot \frac{N_v}{10 + T_v}$ where n_v = length, N_v = precipitation and T_v = mean temperature for the period. (From ÅNGSTRÖM 1958.) G. Geobotanically important rocks: 1. Poor rocks. 2. Jotnian and Cambrian sandstones. 3. Granites, gneisses etc. 4. Rich rocks. 5. Rich paleozoic rocks. 6. Rhaetian-Liassic rocks. 7. Cretaceous rocks. (From SJÖRS 1965.) H. Arable land area: 1. $> 2/3$. 2. $1/3 - 2/3$. 3. $< 1/3$. 4. No arable land. I. Number of inhabitants per km^2 (1950) in rural areas. (B and H—I from

ATLAS ÖVER SVERIGE.)

I. Biotopes in the Aneboda Region

General Description of the Region

Through the works of EINAR NAUMANN (e.g., 1917, 1922, 1923) the limnologic conditions within the Aneboda region, situated in central South Sweden, early became known and it may be looked upon as one of the classic oligotrophic regions. In fact, the first lines of direction of the regio-limnologic thinking were drawn up by NAUMANN in comparing the conditions of the Aneboda region with the conditions of eutrophic regions in South Sweden. Later on more or less comprehensive descriptions of the limnologic characteristics have been given by several authors dealing with special problems within the region, e.g., THUNMARK (1931, 1937, 1942, 1945 a, 1945 b), ÅBERG & RODHE (1942), and MALMER (1960, 1961, 1962 a, 1962 b).

Observations on *Phragmites communis* are given from biotopes in 6 lakes, viz., Fiolen, Stråken, Helgasjön, Furen, Salen, and Trummen (Fig. 7). All lakes are situated within the upper catchment area of the river Mörrumsån. The whole investigation area lies above the highest shore line.

The bedrock consists of granites, gneisses and porphyries belonging to the Gothian system. The north-south boundary

between the large granite area of Southeast Sweden and the large gneiss region of Southwest Sweden runs through the north end of Lake Salen (Fig. 5 C).

The bedrocks have unfavourable to very unfavourable influence on the fertility of the soil (Fig. 6 G, see also ATLAS ÖVER SVERIGE). The investigation area is situated within the fertility district of Sweden where some of the poorest soil types of the country are found.

Within the region shown in Fig. 7 only 13 % of the total land area was designated arable land in 1944. The surface soils of the cultivated areas consist of moraine sand and fine sand (Swedish "mo"), and only in some valleys, e.g., around Lake Salen, clayey silt occurs.

From the north part of the sampling area, with the lakes Fiolen, Stråken, Helgasjön, and Furen, 60—80 % of the total land area is covered by forest. In a southern zone, including Lake Trummen and most of Lake Salen, the forest area constitutes 40—60 %. The most common tree species are *Picea abies*, *Pinus sylvestris*, *Betula verrucosa* and *B. pubescens*.

Especially in the latter part of the 19th and the first part of the 20th

Fig. 7. Topographical map of the Aneboda region. The location of the biotopes indicated by numbers. Top left: 1, 1 A, 1 B and 2 Fiolen and 3—4 Stråken. Centre: 5—6 Helgasjön and 7 A—D Furen. Bottom left: 8 Salen. Bottom right: 9 A—B Trummen. Compare Fig. 4.



century, when the rural population density was greater, a great many of the lakes were lowered in order to enlarge the arable land area. Among the lakes treated here, Fiolen is only slightly, but Furen and above all Salen strongly affected by the lowering.

Sewage and industrial wastes are discharged into several lakes, but Fiolen is also in this respect almost unaffected. Lake Helgasjön is polluted by industrial waste water from a sulphite paper-mill, especially the northern part of Lake Salen as well as Lake Trummen have been heavily auxotrophicated for many years by the discharge of sewage and industrial wastes. In Lake Stråken and Furen sewage from separate houses is discharged, causing auxotrophication with initially local effect.

Climate characteristics are given partly in Figs. 5—6 and partly in Fig. 8. The prevailing wind direction in the region is southwest.

Lake Fiolen

With Biotopes 1, 1 A, 1 B and 2

General Description

57°5'N, 14°32'E. Altitude 226 m a.s.l. Area 1.6 km². Max. depth 10 m.

Lake Fiolen has long been an attractive object for limnologists. NAUMANN (1917), LUNDQVIST (1925), and HANSEN (1962) described the sediments. These, as well as other geologic conditions, were also treated by THUNMARK (1931). Information about physical and chemical properties of the water is given by, e.g., THUNMARK (1937), ÅBERG & RODHE (1942), and MALMER (1960, 1961). Planktologic studies were carried out by CARLIN (1939), RODHE (1941), THUNMARK (1945 b), and BERZIŅŠ (1951). LANG (1931) investigated the macrozoobenthos and CRONHOLM (1946) the water-mite fauna.

A comprehensive description of the macrophyte vegetation is given by THUNMARK (1931). Cf. lakes of the "Fiolen type" in the lake typology. Data on standing crop and biometric analyses of *Equisetum fluviatile* are given by BJÖRK (BJÖRK & DIGERFELDT 1965, p. 313 ff.). The zonation of the lichen vegetation is described by SANTESSON (1939).

The basin of Lake Fiolen is developed by glacial excavation. The drainage area is small, 7.5 km², and does not include any greater mire areas. The water is oligohumic and poor in electrolytes.

There is a dam in the outlet and the water level seldom is lower than the dam threshold. The difference between spring high water level and summer low water level is only ca. 40 cm (THUNMARK 1931, p. 22), occasionally 60 cm (SANTESSON 1939, p. 14).

As the prevailing winds are from the southwest, the sediment limit is situated lower along the eastern shore (ca. 375 cm) than along the western shore (ca. 125 cm).

The frequency of *Nostoc Zetterstedtii* is locally high in a zone between ca. 1 and 3 m, and the frequency is especially high in shallow depressions in the bottom. Sometimes a bright olive-green gyttja is developed from such *Nostoc* concentrations.

Lake Fiolen is still fairly little affected by human activity. In the most affected part, the southern bay "Sörgårdsviken" (bathing place, watering-place for cattle), the frequency of *Lemna minor* within and around a luxuriant stand of *Calla palustris* has been high since the beginning of the fifties. The list of macrophytes given by THUNMARK (1931) does not include *Lemna minor*.

Due to the decreased supply of humic water to Fiolen (THUNMARK 1931, p. 23) the transparency of the water has successively increased. The summer transparency given by THUNMARK (loc.c.) is 460 cm. Occasionally, as in July 1928, it was as high as 500 cm, designated as an extreme value. In July 1935 it was 550 cm (THUNMARK 1937) and the extreme values obtained in the summer 1937—1938 were 500—700 cm (ÅBERG &

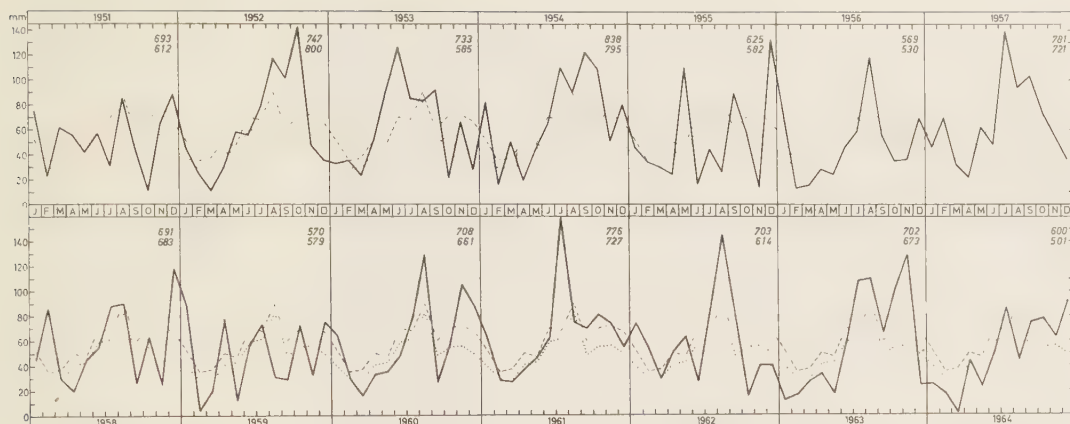


Fig. 8. Precipitation per month in Aneboda I (1963—1964) and II (1951—1962, solid line for both periods and stations) and the monthly mean precipitation for the international period 1901—1930 in Aneboda II (broken line) and Växjö (dotted line). Top right figures for yearly precipitation in Aneboda (above) and Växjö.

RODHE 1942). Random determinations made by the present author in later years have given the values 530 (Sept. 1957) and 650 cm (Sept. 1956).

As the exchange of water between the pelagic area and the littoral zone is lively, there are, from a qualitative point of view, mostly no or only small differences in the water from the superficial layer between these parts of the lake. Concerning water quality data the reader is therefore referred to the descriptions of the *Phragmites* biotopes (Table 5).

Biotope 1

A. Environment

Situation (Fig. 7). Outside the north-eastern shore at Älgadal.

Physiographic survey. Along the shore line, having a NNW—SSE direction, is a boulder barricade pushed together by the ice. Above this is cultivated ground and areas with coniferous and mixed coniferous broad-leaved forest.

The barricade, especially the upper part of it, is overgrown by bushes of *Alnus*, *Betula*, *Fraxinus*, *Rhamnus*, *Salix*, and *Sorbus*. The biotope is overshadowed in the morning, especially in the latter part of the vegetation period. As the winds are prevailing south-

westerly, the biotope has an exposed position and the wave action is considerable.

Besides *Phragmites communis* the following macrophyte species were noted in the investigated area: *Eleocharis palustris*, *Equisetum fluviatile*, *Juncus bulbosus*, *Littorella uniflora*, *Lobelia dortmanna*, *Lysimachia thyrsiflora*, and *Ranunculus flammula* v. *reptans*. All species were represented by only single shoots or a few individuals.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 5). The water depth varied from 10 to 55 cm. The quality of the surface water was stable. Thus the specific conductivity in 7 water samples (Sept. 1956, Sept. 1957, May, June, July, Sept., Dec. 1963) varied from 46 to 48 μS , $m=47$. On the same occasions pH varied from 6.4 to 7.0, $m=6.8$, and the water colour from 5 to 10.

The bottom (Figs. 9—11). The biotope was situated within the erosive zone (=upper part of the asedimentary bottom, cf. THUNMARK 1931, p. 38). This zone was here poor in free-lying boulders, but stones with a diameter of ca.

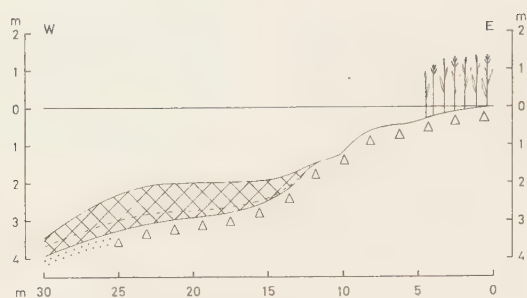


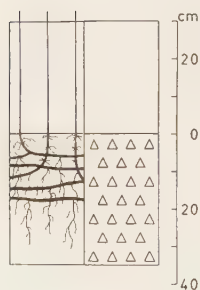
Fig. 9. Lake Fiolen. Stratigraphic section through biotope 1.

15 cm were very common. The bottom was, however, rich in boulders, from which only a small portion was visible from the bottom surface. Therefore, the erosion of the ice was restricted to the most superficial bottom layer and did not cause any damage on the *Phragmites* rhizome and root system.

Stratigraphy (Fig. 11):

0—3 cm Brownish gravelly sand. The thickness and the granulometric composition of the superficial soil (washed moraine) showed considerable variation within small distances.

3—35 cm Very hard (very firmly packed) grey moraine sand, down to ca. 10 cm somewhat rust-coloured.



Biotope 1B
640908

WWS	DM	IL	NPC	H ⁺	Met	Na		K		Mg	Ca	Fe
						a	b	a	b			
2100	1730	0.8	85	7	41	0.60	0.84	0.61	0.50	7.6	7.2	1.0
2200	1930	1.0	90	8	69	0.79	1.24	0.98	0.77	11.7	21	0.1
2220	1950	0.8	88	9	68	0.82	1.29	0.77	0.74	12.8	19.0	1.9
2240	2000	0.9	76	21	66	1.12	1.37	0.91	0.80	12.4	17.5	5.9
2240	1980	1.0	78	20	69	1.03	1.18	1.02	0.71	10.2	15.7	6.4
2270	2050	0.6	80	17	66	0.89	1.18	1.00	0.79	8.7	13.5	8.0
2210	1990	0.4	82	14	62	0.91	0.99	0.75	0.75	7.3	12.0	11.0
2100	1830	0.7	87	9	59	1.12	1.16	0.67	0.55	10.2	16.8	1.4
2110	1880	0.4	86	11	67	1.03	1.01	1.22	1.09	10.2	18.6	7.8

Fig. 11. Biotope 1 Fiolen 631201. Vertical section and soil analyses. Analyses from biotope 1 B also included.

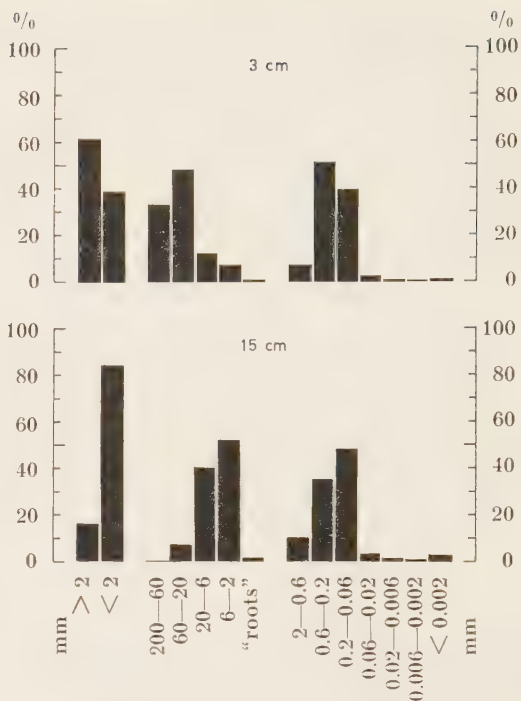


Fig. 10. Biotope 1 Fiolen. Granulometric analysis of soils from two levels. The columns give the weights (in %) of different fractions.

The differences with respect to the proportions of different grain fractions between the superficial washed soil layer and the underlying, very hard moraine are shown in Fig. 10. The data given there refer to samples taken at random

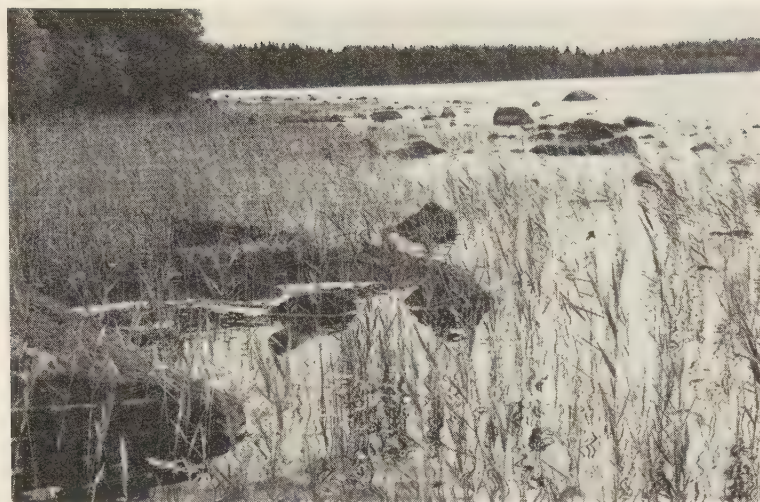


Fig. 12. Biotope 1 B Fiolen.
— Photo S. Björk 640908.

within the investigated area. The presence of a firmly packed Archaean moraine is typical of considerable shore reaches in the lakes within the Aneboda region (cf., e.g., biotope 3 in Lake Stråken, p. 43).

The superficial, washed, sandy soil showed the lowest amount of extractable metallic cations. The homogeneity with respect to this quality of the unwashed moraine throughout the vertical section is shown by a series of analyses of samples taken at every 5 cm (Fig. 11). The amounts of extractable Na and K were about the same at all levels in the moraine, but as for Mg and Ca there was a trend of downwardly decreasing concentrations while Fe increased in the same direction.

B. *Phragmites communis*

Rhizomes and roots (Fig. 11). The main part of the horizontal rhizomes was found between 5 and 12 cm. Below 15 cm the frequency was low and at about 20 cm rhizomes occurred very occasionally. Undulated thick and fine roots were found down to ca. 30 cm.

The occurrence of roots on the basal shoot node was very rare.

Shoot density. Ca. 10.

Flowering time. Second to third week in Sept. The panicles of the shoots growing at the base of the barricade begin to flower at least one week earlier than in the biotope.

Panicle frequency. Ca. 50 %. The differences in panicle frequency between different years were small, viz., ca. ± 5 % (1954—1963).

Further data in Tables 7—10, 12, 14—15.

Biotopes 1 A and 1 B

Situation (Fig. 7). Ca. 400 resp. ca. 650 m ("Klangsviken") to the southeast of biotope 1.

Broadly speaking the physiographic conditions resemble those in biotope 1 (Fig. 12). For water quality and bottom conditions see Table 5 and Fig. 11.

The *Phragmites* reed-beds along the north-eastern shore of Lake Fiolen are of the characteristic sparse type represented in the biotopes 1, 1 A, and 1 B. The highest shoot densities were found in sheltered areas as, e.g., landwards from boulders.

Data on biometry in Tables 8, 10, 14.



Fig. 13. Biotope 2 Fiolen.
— Photo S. Björk 620813.

Biotope 2

A. Environment

Situation (Fig. 7). Outside the west shore at Skog.

Physiographic survey (Fig. 13). Above the minerogenic bouldery shore with approximate N—S direction are grazed pastures with scattered trees. The biotope, situated ca. 25 m from the shore line, is exposed to wind and light except from the west. The wave action is, however, fairly weak.

In shallow water close to the shore there is a zone with low *Phragmites* and then, outside the sediment limit, a zone with tall *Phragmites* growing in fairly deep water (Fig. 14). The biotope was situated in the middle part of the last-mentioned zone.

The quantitative development of the macrophyte vegetation in the stony erosive zone is very sparse, consisting mainly of scattered shoots and individuals of *Eleocharis palustris*, *Equisetum fluviale*, *Lobelia dortmanna*, and *Phragmites communis*. Lakewards, on inerosive bottom, the frequency of the isoetids increases, and in the biotope there is a dense carpet of *Isoetes lacustris* and *Lobelia dortmanna*.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 5). The quality of the surface water was stable. Thus the specific conductivity in 8 samples taken during the period 1954—1964 (June 1954, Sept. 1956, July, Sept. 1957, Sept. 1962, July, Nov. 1963, Sept. 1964) did not vary more than from 46 to 48 μS , $m=47$. On the same occasions the pH varied from 6.5 (Nov. 29, 1963) to 7.4 (June 23, 1954), $m=6.9$. The water colour alternated between 5 and 10.

Interstitial water was obtained by suction of fresh and frozen gyttja samples. In comparison with the water obtained from the fresh soil samples, the water from the frozen samples had a lower specific conductivity (70—80 % of that for the fresh samples) and with respect to different qualities the water from the fresh samples showed greater variations between different levels than the water from the frozen samples. Without doubt the evaporation during the long time of suction of the fresh samples at least in part was the cause of the rise in the ionic concentration of the obtained water. Only data for

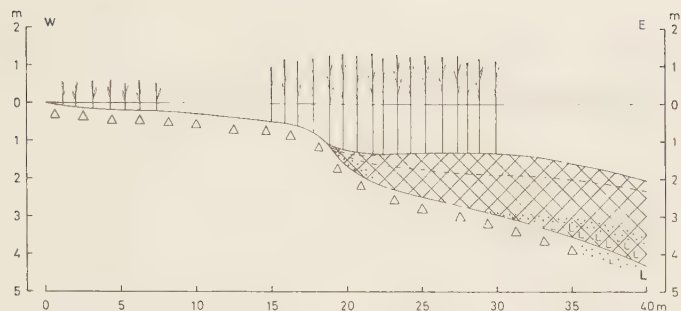


Fig. 14. Lake Fiolen. Stratigraphic section through biotope 2.

water from frozen soil samples are given in Table 5.

The interstitial water obtained from frozen gyttja had a specific conductivity about twice that of the surface water. In the interstitial water the K concentration and especially the content of Fe was considerably higher. The increase of Mg was relatively higher than that of Ca. In the upper soil layers the Cl concentration was lower than in the surface water. However, in the vertical section there was a marked downward increase in the Cl concentration.

The bottom (Figs. 14 and 15).

Stratigraphy:

- 0—11 cm Fairly dark brown gyttja.
- 11—21 cm Light brown gyttja.
- 21—24 cm Dark brown ochre with granular structure.
- 24—44 cm Light-coloured ochre with granular structure.
- 44—142 cm Gyttja: 44—55 cm beige; 55—58 olive-green-beige, buttery, with very high frequency of *Isoëtes* macrospores; 58—62 grey-beige; 62—64 bright olive-green *Nostoc* gyttja; 64—66 grey-beige; 66—69 bright olive-green *Nostoc* gyttja; 69—85 green-beige to grey-beige, very rich in *Isoëtes* macrospores; 85—88 bright olive-green *Nostoc* gyttja; 88—92 brown-beige; 92—93 bright olive-green *Nostoc* gyttja; 93—142 downwards

darker brownish gyttja. Thin layers of *Nostoc* gyttja at 103 (included in the analysed sample) and at 112 cm. Here and there very high frequency of *Isoëtes* macrospores, especially in the upper part.

142—145 cm Brown to dark grey gravelly sand.

The very complicated stratigraphy was plainly reflected in some of the analytically determined properties of the soil. In the superficial ochre layers the redox potential was from +260 to +290 mV in Nov. 1963 (pH 6.6 resp. 6.0), the highest value was obtained in the light ochre. In the underlying gyttja the E_h values became negative, viz., -120 at 57 cm (pH 6.7), -170 at 83 cm (pH 6.6) and -160 at 108 cm (pH 6.6).

The amounts of extractable metallic cations showed considerable variations between layers of gyttja of different kinds. The lowest value was obtained from the light ochre and the highest values from layers containing *Nostoc* gyttja. From these soil samples very high amounts of Fe were extractable. A slight increase downwards in the extractable amounts of Na and K was found, but the highest Mg and Ca values were obtained from the two uppermost sampled layers with precipitated iron.

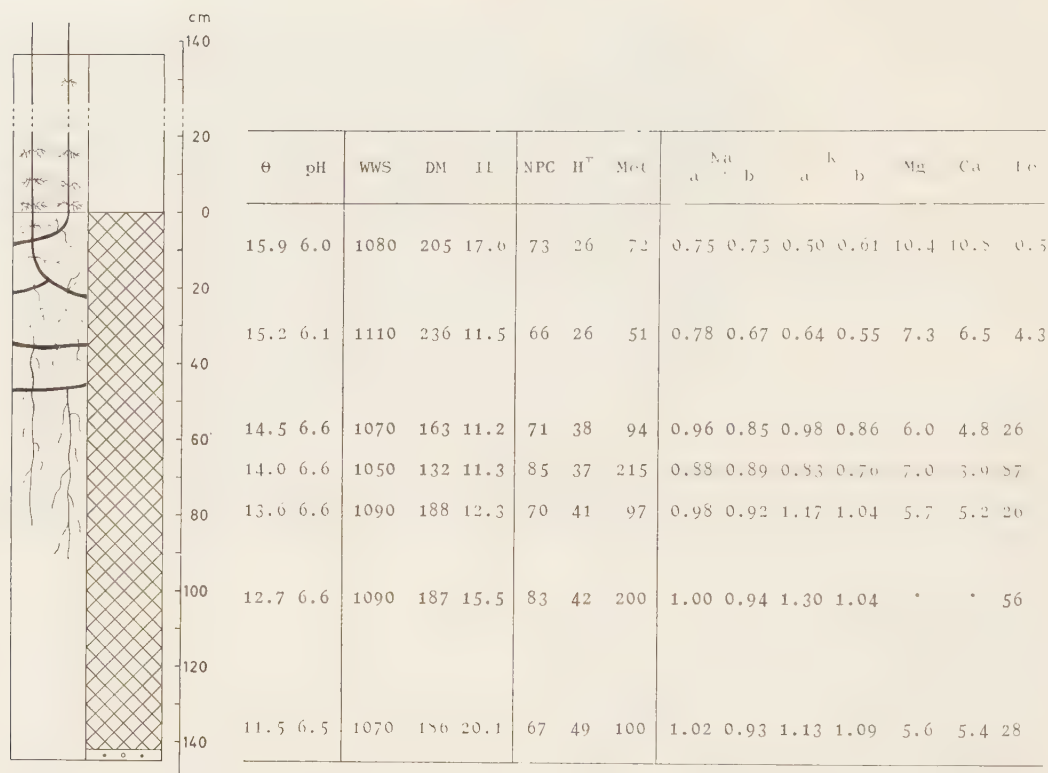


Fig. 15. Biotope 2 Fiolen 640907. Vertical section and soil analyses.

B. *Phragmites communis*

Rhizomes and roots (Fig. 15). Many horizontal rhizomes were growing superficially, but rhizomes were found down to ca. 50 cm. The rhizome internodes were characteristically flattened. From drawn-up rhizomes thick roots with a length of up to at least 85 cm were found, but it was not determined with certainty whether roots of this kind could penetrate the soil downwards to their full length. No concentrations of fine roots were found at any soil level. Bushy fine roots occurred up to the 8th to 10th node of some shoots, i.e., up to ca. 100 to 125 cm above the bottom. (The roots of *Lobelia dortmanna* reached down to ca. 10 cm and the roots of *Isoetes lacustris* to ca. 25

cm. Thus the uppermost analysed soil sample emanated from the middle part of the layer penetrated by the roots of the isoetids.)

Shoot density. Ca. 4.

Flowering time. During the observation period 1952 to 1965 no flowering panicles were observed. As late as in the middle of Sept. only a small portion of the panicle was visible outside the upper leaf vagina.

Panicle frequency. In some years, as, e.g., in 1962, no panicles were developed at all. In, e.g., 1957, the frequency of partly grown-out panicles at the end of the vegetation period was 19 %.

Further data in Tables 7, 9—10, 12, 14—15.

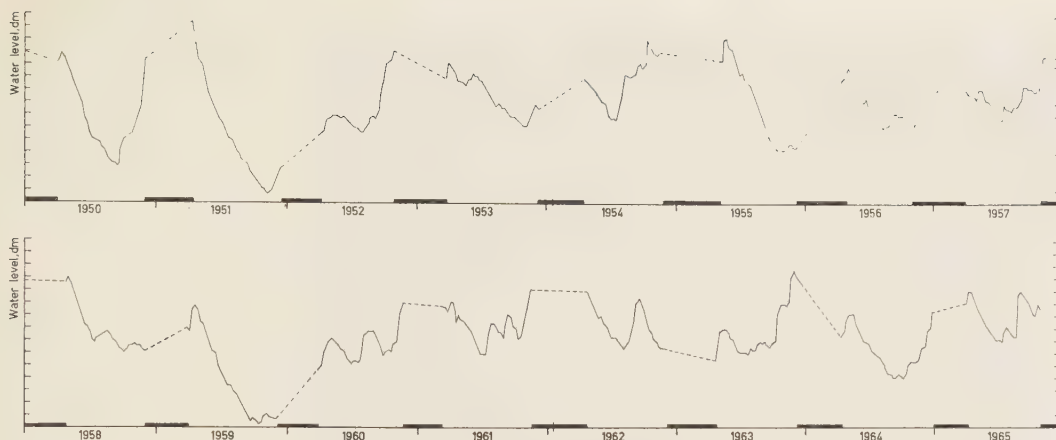


Fig. 16. Lake Stråken. Water level fluctuations. Compare Fig. 8.

Lake Stråken

With Biotopes 3—4

General Description

57°6'N, 14°36'E. Altitude 185 m a.s.l. Area 8.2 km². Max. depth 12.5 m.

Most of the several investigations dealing with Lake Stråken have been carried out in the north enlargement (Aneboda Limnological Laboratory situated here at the western shore). Sediment descriptions are given by NAUMANN (1917), LUNDQVIST (1925), and HANSEN (1962). Physical and chemical conditions of the water were analysed by, e.g., THUNMARK (1937), ÅBERG & RODHE (1942), and MALMER (1961). Planktologic studies were carried out by RODHE (1941) and BĒRZIŅŠ (1951). LANG (1931) and BRUNDIN (1949) investigated the macrozoobenthos and CRONHOLM (1946) the water-mite fauna.

The macrophyte vegetation of the northern part of Lake Stråken was described by BLOMGREN & NAUMANN (1925) and given as a typical example of the conditions in a mesohumic lake within the Aneboda region. In comparison with Lake Fiolen the ephydate and hyperhydate vegetation has a quantitatively richer but the isoetids a weaker development in Stråken. The zonation in the lichen flora was investigated by SANTESSON (1939).

Lake Stråken is a rock basin formed by glacial excavation. The water level is regulated (Fig. 16).

The northern part of Stråken receives water from a small stream draining the Åkhult mire and due to the precipitation conditions the humus content of the water in the lake is variable. BLOMGREN & NAUMANN (1925) give the extreme transparency values 140 (July 1924) and 360 cm (June 1909), THUNMARK (1937) 460 cm (July 1935), and ÅBERG & RODHE (1942) the extreme values 310 and 530 cm from the years 1937—1938. The water colour values given by the latter authors are 18—39. In the author's water colour analyses from June and July in 6 years during the period 1956—1965 the extreme values are 10 and 45.

There is a lively exchange of water between the pelagic area and littoral zones with sparse ephydate and hyperhydate vegetation of more or less original character, and no or only small differences in the quality of the water from the superficial layer are establishable between these regions. However, in littoral reaches with local auxotrophication and luxuriant macrophyte vegetation the water quality is often markedly different from that of the pelagial.

Biotope 3

A. Environment

Situation (Fig. 7). On the south side of the southeastern cape of the island of Ugglehultsön. The biotope is seen in the



Fig. 17. Biotope 3 Stråken.
— Photo S. Björk 620828.

background in Figs. 3 and 4 in Plate V in BLOMGREN & NAUMANN 1925.

Physiographic survey (Fig. 17). The whole island, built up in part of Archaean rock but in the main of moraine, is covered by mixed coniferous broad-leaved forest. Along the bouldery shore with E—W direction there is a zone with *Alnus glutinosa* bushes, *Myrica gale*, *Molinia coerulea*, and *Lythrum salicaria*.

The biotope is exposed to light and winds from the south. The wave action can be considerable.

The *Phragmites* stand was intermingled with a sparse vegetation of *Eleocharis palustris*, *Equisetum fluviatile*, *Glyceria fluitans* (single small individuals), *Juncus bulbosus*, *Littorella uniflora*, *Lobelia dortmanna*, *Lysimachia thyrsiflora*, *Ranunculus flammula* v. *reptans*, and *Subularia aquatica*. In isolated, sheltered areas close to boulders there were small carpets of *Littorella uniflora*.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 5). The water level fluctuations in Lake Stråken are described in Fig. 16. On the basis of the weekly made measurements it can be stated that the water depth in biotope 3 varied from 0 to ca. 75 cm during

the observation period 1961—1965. The mean water depth during the five periods May—Sept. was ca. 25 cm and the extreme values 0 and ca. 60 cm.

The colour of the surface water in the biotope varied from 15 (Sept. 1964) to 60 (Dec. 1963). In four samples (Aug., Sept. 1962, Dec. 1963, Sept. 1964) the specific conductivity varied from 47 to 54 μS , $m=50$, and pH from 6.2 to 6.8, $m=6.6$. In Dec. 1963 the content of total P was 0.7 $\mu\text{mol/l}$.

Interstitial water from the surface soil layers was sampled in dug pits during low water in Sept. 1964. The conductivity was about four times as high as in the surface water. The rise in the conductivity was in part due to the higher concentrations in the interstitial water of Mg and Ca.

The bottom (Figs. 18—19). The bottom surface was to a large extent covered by stones and also boulders occurred. The latter are slightly pushed towards the shore line by the ice. There are furrows behind some of the

larger boulders and small mounds of bottom material in front of them.

Stratigraphy (Fig. 19):

- 0—ca. 10 cm Rust-coloured, stony and gravelly sand. (The thickness of the rust-coloured layer varied within small horizontal distances from ca. 5 to ca. 10 cm.)
- Ca. 10—47 cm Grey Archaean moraine, in the uppermost part washed, but with downwardly increasing content of fine sand and silt. This soil is very hard (very firmly packed).

The highest values for extractable metallic cations were obtained from the superficial rust-coloured layer. On the other hand, the highest percentage of neutralization was found in the unwashed, very hard silty moraine.

B. *Phragmites communis*

Rhizomes and roots (Fig. 19). The horizontal rhizomes were concentrated between ca. 5 and ca. 18 cm. Strongly undulated thick and fine roots were found down to ca. 30 cm. The frequency of fine roots was high in the



Fig. 18. Biotope 3 Stråken. The emerged stony bottom. Scattered individuals of *Lobelia dortmanna* and small stands of *Littorella uniflora*. — Photo S. Björk 640908.

surface layer down to ca. 12—15 cm. Shoot density. Ca. 18.

Flowering time. Normally during the first to second week in Sept.

Panicle frequency. In some years (e.g. 1961, 1964) the panicle frequency amounted to ca. 30—40 %, but in 1962 it was only ca. 1 %. In 1962 the panicles were very small and were developed so late that they did not flower at all.

Further data in Tables 7—10, 14—15.

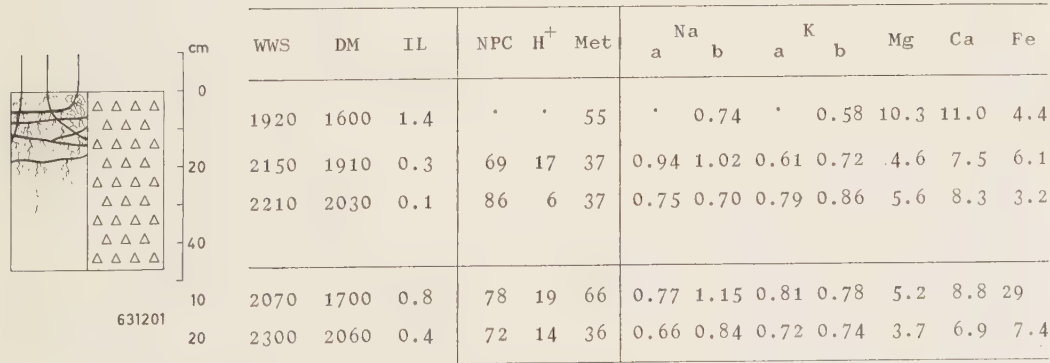


Fig. 19. Biotope 3 Stråken. Vertical section and soil analyses from 631201 and 640908.

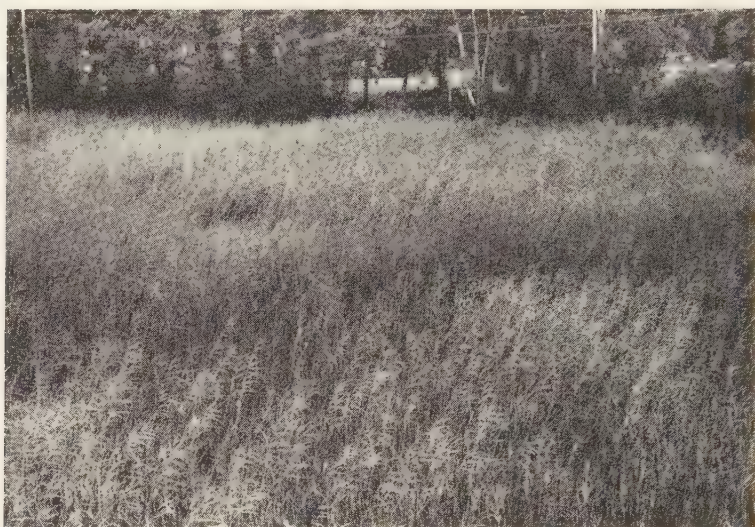


Fig. 20. Biotope 4 Stråken.
— Photo S. Björk 660903.

Biotope 4

A. Environment

Situation (Fig. 7). In the innermost part of the sheltered bay ca. 100 m north of the church of Aneboda.

Physiographic survey (Fig. 20). Along the shore there is a girdle of trees and bushes of *Alnus* and *Betula*, landwards followed by grassed and cultivated ground. The biotope is exposed to the east. Due to the quantitatively rich development of the hyperhydric vegetation lakewards from the biotope, it is fairly sheltered also against eastern winds. In the latter part of the vegetation period the biotope is overshadowed early in the afternoon (in the end of Aug. already from 2 p.m.).

For many years sewage from two houses has been let out, via a septic tank, into the bay. The biotope was situated in the most homogeneous part of the luxuriant *Phragmites* stand around the sewage outlet.

The water surface was totally covered by *Lemna minor*. Otherwise no other macrophyte species but *Phragmites communis* occurred. Along the shore *Solanum dulcamara* and *Bidens tripartita* were common.

As a rule the dry *Phragmites* stems were broken in the spring.

The water (Table 5). As for water level variations cf. biotope 3 and Fig. 16.

The quality of the surface water was very variable and dependent on water depth, the exchange of water between the lake and the overgrown bay and on the supply of sewage. When the water depth decreased, the possibilities for water exchange also decreased and the relative amount of sewage became greater; the rise in the concentrations of Na, K, and Cl was then especially noticeable.

The bottom (Fig. 21). The surface of the more or less consolidated superficial gyttja layer was covered by very coarse and loose *Phragmites* detritus.

Stratigraphy:

0—20 cm	Dark brown loose and coarse <i>Phragmites</i> detritus with downwardly increasing amount of fine detritus. Smell of sewage noticeable in upper part.
20—ca. 35 cm	Greyish sandy gravel rich in drift material.
ca. 35—ca. 54 cm	Strongly sandy and gravelly drift gyttja, rich in big pieces of

wood, dead rhizomes and roots of *Equisetum*.

ca. 54—ca. 86 cm Grey-brown gravelly sand with drift material of finer fractions than in the overlying layer. Stones occurred here and there. Dead *Equisetum* rhizomes common.

ca. 86—ca. 107 cm Fairly loose grey clayey silt.

ca. 107—125 cm Grey hard, silty, fine sand. In the upper part nearly pure fine sand, in the lowermost part some stones.

The sandy layer in the middle part of the vertical section showed the lowest

amount of extractable metallic cations and the lowest percentage of neutralization. Above and below this layer the amounts of extractable metallic cations as well as the percentage of neutralization were higher, the latter character being highest in the purely minerogenic soils below 86 cm. On a volumetric basis the highest content of extractable Na was obtained from the loose superficial soil layer, while the K content here was a little lower than in the hard minerogenic soil in the lower part of the section. In the intermediate layers the extractable amount of K was considerably lower. As for Mg and Ca, the concentrations followed the total amounts of extractable metallic cations.

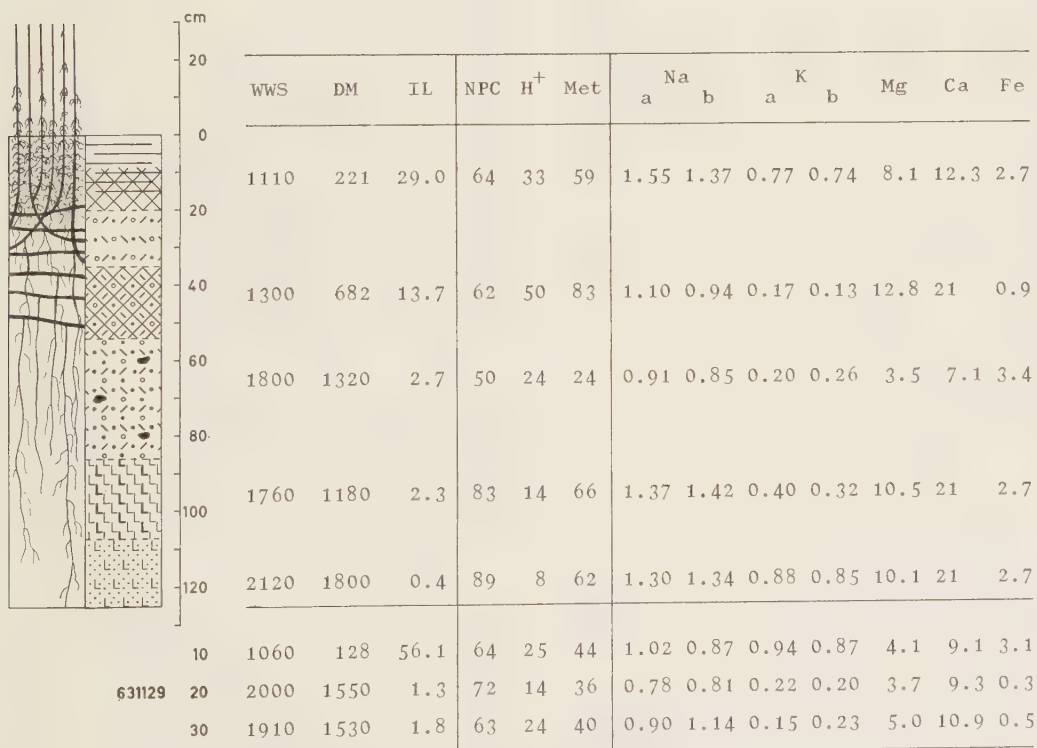


Fig. 21. Biotope 4 Stråken. Vertical section and soil analyses from 631129 and 640909.

B. *Phragmites communis*

Rhizomes and roots (Fig. 21). The main part of the horizontal rhizomes occurred between ca. 20 and ca. 50 cm, the highest concentration being found between 30 and 40 cm. The thick roots, found down to 125 cm (cut off), had a noticeably large diameter (5—6 mm, cf. biotope 35 Krankesjön, p. 145). The highest frequency of fine roots was found in the superficial (20 cm) soil. A fairly rich occurrence of fine roots was also noted in the minerogenic soil between 86 and 107 cm. Practically all shoots had roots on 1—5 nodes.

Shoot density. Ca. 35 (1962).

Flowering time. Dependent on the weather conditions the panicles came into full flower during the period first to third week in Sept. However, in some years, as, e.g., in 1962, many of the panicles, though otherwise normally developed, were not fully grown out and had not come into full flower within this period.

Panicle frequency. Ca. 55 % (1962).

Further data in Tables 7 10, 14—15.

Lake Helgasjön

With Biotopes 5—6

General Description

56°58'N, 14°46'E. Altitude 163 m a.s.l. Area 49.5 km². Max. depth 21 m.

The basin, formed by glacial excavation, is divided into several more or less separated parts and has a main configuration which is H-shaped. The shores are for the most part minerogenic.

The lake is polluted by waste water from the sulphite paper-mill at Böksholm. The pollution situation is described by THUNMARK (1937, 1945 a) and AHL (1962). Judging from

the water analyses AHL (op.c.) considers the natural ionic balance in Lake Helgasjön to have been changed through the pollution from the paper-mill.

Qualitative and quantitative differences in the plankton between different parts of the lake were pointed out by THUNMARK (1945 a). The chironomid fauna was investigated by BRUNDIN (1949).

Biotope 5

A. Environment

Situation (Fig. 7). In the north end, "Svanbroviken", of the narrow bay "Örfjorden", in the middle zone of the reed-bed.

Physiographic survey (Fig. 22). Above the shore (NE—SW direction) the sandy ground is to some small extent cultivated or consists of meadows, but for the main part covered by mixed coniferous forest (*Pinus* and *Picea*). The biotope is exposed to southerly winds and to light from all directions. The wave action can be fairly considerable.

The scattered *Phragmites* reed-bed follows the shore line, but at a distance varying from 10 to 30 m. With the exception of some few scattered stands of *Eleocharis palustris* and scattered individuals of *Lobelia dortmanna* there was in this *Phragmites*-free zone hardly any macrophyte vegetation at all.

Within the biotope only some single shoots of *Equisetum fluviatile* and isolated individuals of *Lobelia dortmanna* and *Ranunculus flammula* v. *reptans* were noted. East of the biotope the *Phragmites* stand was within a restricted area intermingled with *Scirpus lacustris*. In this mixed stand the *Phragmites* shoots were considerably lower and more scattered than in the other, more or less pure, part of the reed-bed.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 5). Due to topographic and hydrologic conditions Örfjorden, though affected by the pollution (THUNMARK 1945 a, p. 44), is among the parts least influenced by the waste water discharge into Helgasjön.



Fig. 22. Biotope 5 Helgasjön. — Photo S. Björk 640730.

The specific conductivity of the surface water was 62 μS in June 1954, 64 in Aug. 1954, 78 in Sept. 1962, 80 in Dec. 1963 (high water level; water depth in the biotope 90 cm), and 87 in July 1964 (low water level; water depth in the biotope 25 cm). [THUNMARK (1937) gives the value 60 μS from the south-western part of Helgasjön.] This series of data gives the impression that the ionic concentration of the water in Örfjorden has increased during the last decade.

The bottom (Figs. 23 and 24). The surface consists of pure sand except in shallow depressions where detritus is accumulated in thin layers.

Stratigraphy:

- 0—45 cm Grey sand, at about 15 cm containing organogenic matter and relatively more fine sand.
- 45—50 cm Fine sand with organogenic drift material.

From one of the obtained soil cores, given as an example in Fig. 23, samples were taken at small vertical intervals. In the sandy layer down to 40 cm the amounts of extractable metallic cations as well as the percentage of neutralization were about the same at all levels

except at 15 cm. At this level the sand was somewhat intermingled with organic matter and also contained granulometric finer minerogenic fractions. In the analyses this is noticed by higher loss on ignition and higher amount of extractable metallic cations. As to the lowermost sampled level (i.e., in the soil rich in drift matter) similar conditions were established. At both levels the percentage of neutralization was relatively lower.

With respect to the vertical distribution of the analysed extractable elements, only K showed a concentration gradient, viz., a downward decrease.

The stratigraphic conditions described here have been found in several *Phragmites* biotopes in central South Sweden, as, for example, in the northernmost part of Lake Stråken and the north-western part of Lake Hindsen (north-east of the town Värnamo). The soil layer containing drift material was developed during a period with relatively high water level. This soil was covered by sand swept down in connection with the following regression. Below the soil with drift material there is usually a blue-grey sandy, silty or clayey soil.

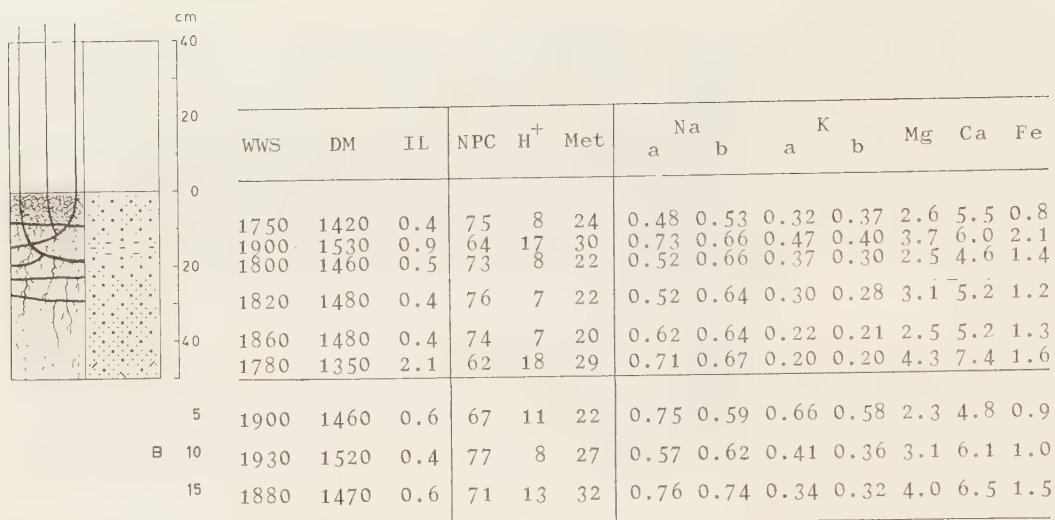


Fig. 23. Biotope 5 Helgasjön 631202. Vertical section and soil analyses (two cores).

B. *Phragmites communis*

Rhizomes and roots (Fig. 23). The highest frequency of horizontal rhizomes was found between 8 and 17 cm, but rhizomes occurred down to at least 30 cm. Fine undulated roots were observed throughout the section and were fairly frequent also in the drift soil formation. A dense fine root felt was developed down to ca. 7 cm. On some few shoots there were roots on one to two of the basal nodes.

Shoot density. In 1951 ca. 25, in 1953 and 1955 ca. 23, and in 1964 ca. 14. The successive quantitative de-

crease was observed and pointed out also by the local inhabitants.

Flowering time. In the zone of the reed-bed within which the biotope was situated only very few panicles were noted during the whole observation period. They came into full flower during the period of the second and third week in Sept.

Panicle frequency. In the years 1951, 1953, 1955, and 1964 0 %.

Further data in Tables 7, 10, 12, 14—15.

Additional notes. A section perpendicular to the shore line was laid out through the whole reed-bed, in-

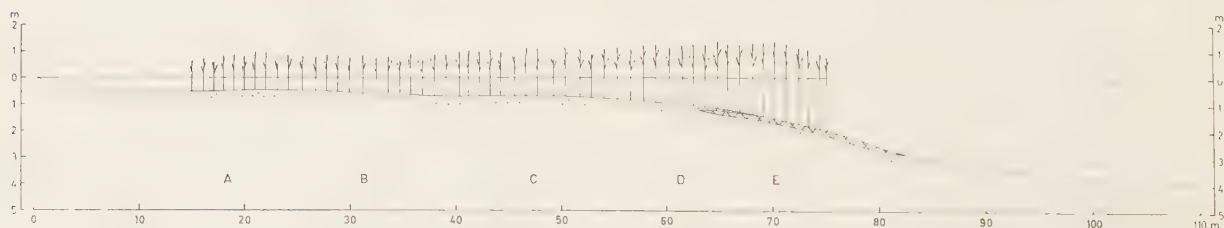


Fig. 24. Lake Helgasjön. Stratigraphic section through biotope 5. The outer part of the reed-bed growing in iron ochre. A—E indicate sampling sites for shoots analysed in Table 11.

Fig. 25. Lake Helgasjön. The transition zone between the sparse stand part with biotope 5 (cf. Fig. 22) and the dense stand part with biotope 6 — Photo S. Björk 640730.



cluding the biotope 5 area, in order to make biometric studies on *Phragmites* growing in different water depths. See Fig. 24.

In this case it was stated, that the shoot length and weight, the leaf number, length and breadth and with that the leaf area per shoot increased lakewards and landwards (Table 11) from a zone some distance outside the inner margin of the reed-bed. (Cf. the section described on pp. 134—135 from biotopes 31 A—D Jägern.)

Biotope 6

A. Environment

Situation (Fig. 7). Ca. 20 m east of biotope 5.

Physiographic notes (Fig. 25). As for exposition etc. cf. biotope 5. The *Phragmites* stand was quite pure. The dry stems were usually broken in the spring.

The water (Table 5). On the sampling occasions it was not possible to establish any noteworthy differences in the surface water quality between biotopes 5 and 6.

The bottom (Fig. 26). The surface consisted of pure sand.

Stratigraphy:

0—7 cm	Dark grey sand (relatively much fine sand).
7—ca. 15 cm	Gravelly sand.
ca. 15—35 cm	Grey, rather hard, gravelly sand (relatively much fine sand).
35—53 cm	Gravelly and sandy soil with organic drift matter of fairly fine fractions and also containing fine minerogenic fractions.

On the whole the soil at all sampled levels in biotope 6 contained higher amounts of finer minerogenic fractions than in biotope 5. The upper level for the drift soil formation with organic matter was also more superficially situated than in biotope 5. The amount of extractable metallic cations (Mg and Ca) was higher in biotope 6 than at the corresponding levels in biotope 5.

B. *Phragmites communis*

Rhizomes and roots (Fig. 26). The highest frequency of horizontal rhizomes was found between ca. 17 and ca. 30 cm, but rhizomes occurred down to at least 40 cm. Thick as well as fine roots were cut off at 53 cm. The super-

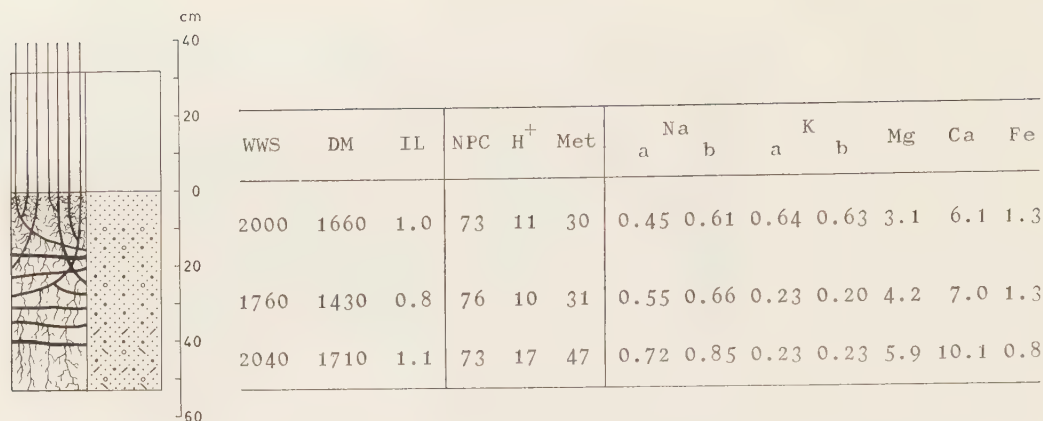


Fig. 26. Biotope 6 Helgasjön 631202. Vertical section and soil analyses.

ficial 10 cm were very rich in fine roots. The roots were not so strongly undulated here as in biotope 5. No roots on the basal shoot nodes were noted.

Shoot density. Ca. 45 during the whole observation period.

Flowering time. First to second week in Sept.

Panicle frequency. Variations from 0 (1962) to ca. 10 % (1951, 1953) were recorded.

Further data in Tables 7—10, 12, 14—15.

Additional notes. Biotope 6 was situated in a stand of tall *Phragmites* growing in a strip about perpendicular to the shore line outside the mouth of a rivulet. The breadth of the strip was ca. 20 m.

During the whole observation period the distribution areas of the small (represented by biotope 5) and the tall *Phragmites* types were constant. The transition zone between the two areas was only 2—3 m (Fig. 25). In this zone there was with respect to the shoot lengths an even transition from one size type to another. The whole stand in Örfjorden in question here seems to belong to the same clone and the differ-

ences in the quantitative development are in this case probably due to environmental conditions. The soil analyses proved that differences in the bottom conditions exist.

Lake Furen

With Biotopes 7 A—D

General Description

56°58'N, 14°38'E. Altitude 151 m a.s.l. Area 4.6 km².

The basin is divided into three well-separated parts. About 1913—1914 the water surface was permanently lowered ca. 1.2 m. At the lowering fine-grained soils (among other things rich in potassium, cf. below) and also organogenic sediments became accessible for hyperhydrites. According to information from the local inhabitants the hyperhydrite vegetation has from a quantitative point of view shown a considerable increase since the lowering took place. Fairly large stands of *Equisetum fluvatile*, *Phragmites communis*, and *Scirpus lacustris* nowadays occur in the lake.

In July 1935 the transparency was 260 cm and the specific conductivity of the superficial pelagic water 72 μS according to THUNMARK (1937). In June 1954 the transparency was 200, in Aug. 160, and in July 1955 160 cm. On these three occasions the conductivity varied from 73 to 76 μS.

Fig. 27. Lake Furen. The reed-bed with biotopes 7 A—D. The photograph taken from the bridge shown in Fig. 28. — Photo S. Björk 530824.



Sewage from separate houses is discharged into Lake Furen, and thus the auxotrophication is locally increased. The *Phragmites* investigation area is situated close to one of the sewage outlets.

Biotopes 7 A—D

A. Environment

Situation (Figs. 7 and 28). At the eastern shore of the southeastern bay, immediately south of the church of Härlöv.

Physiographic survey (Fig. 27). Above the shore line (N—S direction) is a grassy zone with scattered trees of *Alnus* and *Betula*, i.e., the zone permanently emerged after the lowering of the lake. This zone is followed by gardens and other cultivated ground. The biotopes were overshadowed in the morning. They were exposed to western and especially to northwestern winds. The wave action was weak.

The northern limit of the continuous *Phragmites* stand was formed by a bridge (Fig. 28). Just south of this there is, since 1939, an outlet for sewage from one dwelling-house. From another outlet, situated immediately south of the investigated area, sewage has also been discharged into the lake. According to the local inhabitants the *Phragmites* reed-bed at this shore reach is fairly young. In 1939 it consisted of a small stand of low and scattered shoots. However, since

the discharge of sewage began in that year, a rapid increase in the quantitative development took place. Due to the different environmental conditions the quantitative development of *Phragmites* showed great differences between the northern and the southern ends of the investigated area at the beginning of the observation period (1952). However, changes in the quantitative development of *Phragmites* were also noted from one year to another.

The *Phragmites* reed-bed grew up to the shore line, but in a zone outside this it was intermingled with *Carex acuta* and also *Carex elata* and *Carex rostrata* occurred. Lakewards from this zone the *Phragmites* stand was nearly quite pure.

In the north, i.e., the most heavily auxotrophicated part of the investigated shore reach, single shoots and individuals of *Alisma plantago-aquatica* (often only seed-

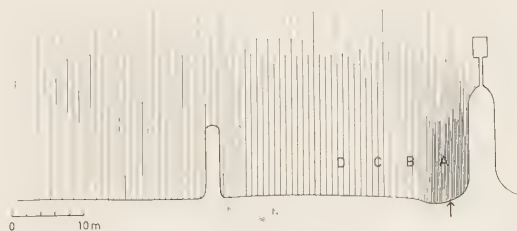


Fig. 28. Lake Furen 530824. Schematic shoot density map of the reed-bed with biotopes 7 A—D. Sewage outlet indicated by arrow.

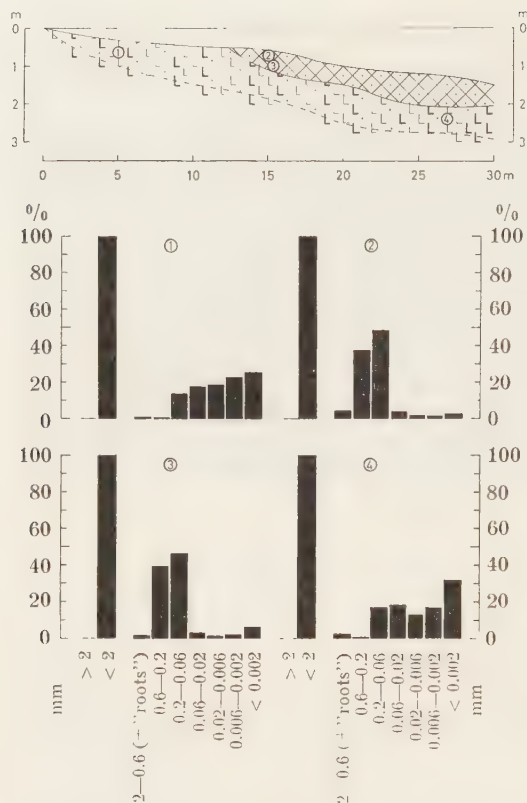


Fig. 29. Lake Furen. Top: Stratigraphic E—W section (seen from N) through biotope 7 D. Broken line indicates the limit between loose and solid clayey silt. Bottom: Granulometric analyses of soil samples from the levels indicated by encircled numbers in the section. Cf. Fig. 10.

lings), *Carex acuta*, and *Lysimachia thyrsiflora* occasionally occurred. The water surface was, however, often covered by *Lemna minor*.

In the middle and southern part single shoots and individuals of *Carex rostrata*, *Eleocharis palustris*, *Equisetum fluviatile*, *Isoetes echinospora*, *Lobelia dortmanna*, *Lysimachia thyrsiflora*, *Polygonum amphibium*, and *Ranunculus flammula* v. *reptans* occurred.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Tables 5 and 6). On the observation occasions during the vegetation period water depths from 0

to ca. 60 cm were recorded in the zone of the *Phragmites* stand within which the samplings of plant material were carried out. On occasions when this zone had emerged, surface water samples were taken in the still submerged part of the *Phragmites* stand, i.e., 1 to 2 m lakewards from the ordinary sampling points. On such occasions part of the sewage was infiltrated into the superficial soil layer in the northernmost part of the area.

The surface water quality in the northern part (sampling site A in Fig. 28) showed considerable variations. Examples of analytical data from two different sampling occasions, one characterized by weak and one by heavy pollution conditions are given in Table 5. The increase in the pollution degree was accompanied by considerable increases especially in the amounts of Na, K, and Cl.

On the other hand, in the southern part (sampling site C in Fig. 28) the quality of the surface water was fairly stable.

Interstitial water was sampled (suction of fresh soil) only once, viz., in Dec. 1963, from ca. 5 cm (water depth ca. 60 cm) in biotope 7 A. In this water the specific conductivity was 240 μ S, and the Cl content 825 μ mol/l. The corresponding qualities of the surface water on the same occasion were 84 and 260 respectively.

The area just outside the sewage outlet was cleaned from macrophyte vegetation now and then. In connection with one of these cleanings a shallow groove was also dug lakewards from the outlet. Of course measures of this kind disturbed the nutrient supply to the luxuriant *Phragmites* stand close to the outlet.

The bottom (Figs. 29 and 30). The clayey silt, which is characterized by being very loose under the superficial more solid and partly sandy layer, is underlaid by solid clayey silt. Lakewards the loose clayey silt is overlaid by gyttja.

Rust-coloured horizons were present from 35 to 46 and from 60 to 78 cm. From 78 to 80 cm very loose (watery) clayey silt.

Stratigraphy in biotope 7A:

- 0— 5 cm Grey sand. Even transition towards underlying clayey silt.
- 5—80 cm Clayey silt with sandy layers. Sandy layers occurred between 35 and 45 and from 55 to 60 cm.

As the figures for loss on ignition are not corrected with respect to the clay content and due to the fact that the content of organic matter is very low throughout the section, the figures for loss on ignition give a fairly good idea about the clay content in the different layers.

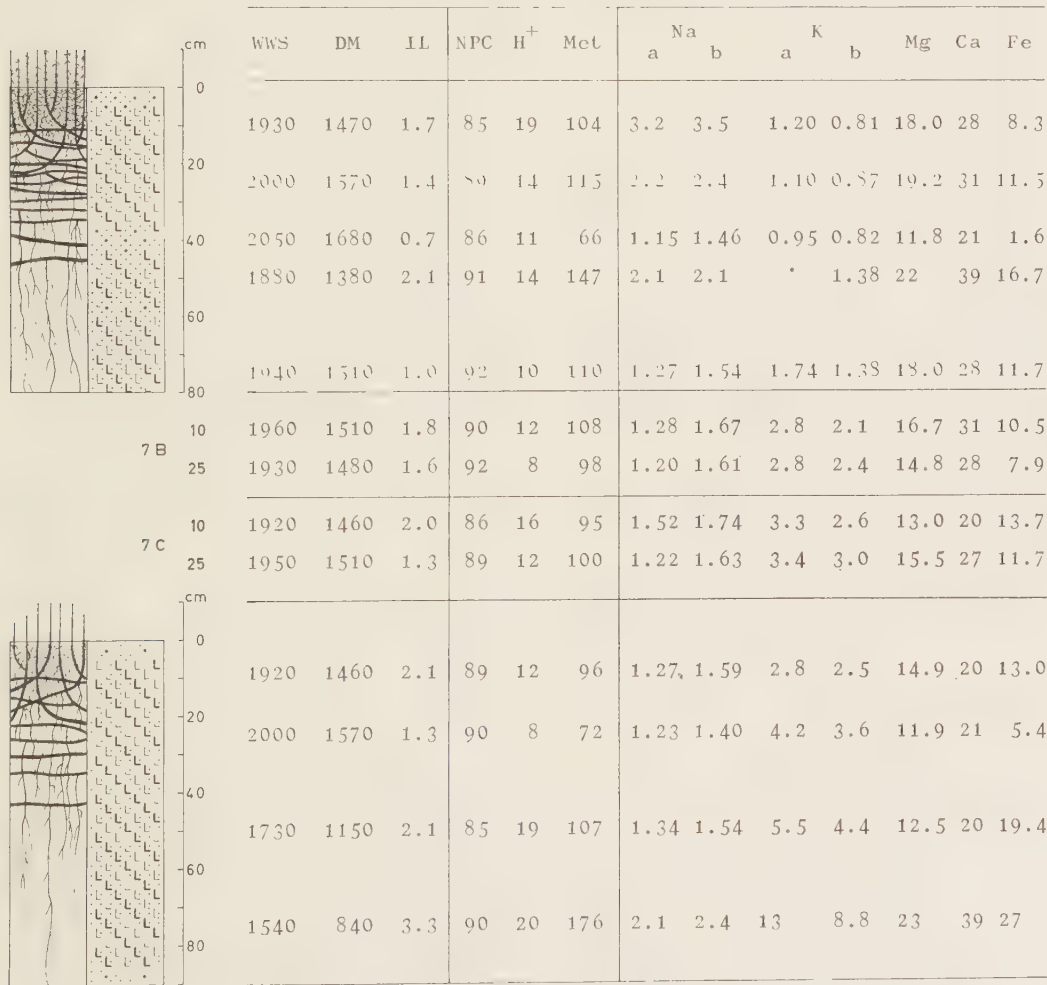


Fig. 30. Lake Furen 640814. Vertical sections and soil analyses from biotopes 7 A (top) — 7 D (bottom).

The sample taken in the sandy layer at 40 cm showed the lowest amount of extractable metallic cations. In the more clayey layers the amounts were considerable higher. The percentage of neutralization was fairly even and high throughout. The highest content of extractable Na was found in the most superficially taken sample (sewage infiltration). The K content was relatively high. As for the content of extractable Fe the sample from 40 cm, as expected, markedly deviated from the other sampled levels.

Stratigraphy in biotope 7B:

- 0—ca. 3 cm Sand.
- ca. 3—40 cm Fairly solid clayey silt with sandy layers.
- 40—90 cm Loose (watery) clayey silt.

The extractable amounts of metallic cations as well as the percentage of neutralization about the same as at the corresponding upper sampled levels in biotope 7A. However, the amount of extractable K was considerably higher.

Stratigraphy in biotope 7C:

- 0—ca. 5 cm Sand.
- ca. 5—ca. 40 cm As in biotope 7B.
- ca. 40—ca. 90 cm As in biotope 7B.

Extractable metallic cations and percentage of neutralization at 10 and 25 cm about the same as in the two preceding biotopes, but the content of K still higher here.

Stratigraphy in biotope 7D:

- 0—5 cm Sand.
- 5—90 cm Clayey silt with sandy layers. Between 20 and 60 cm dark (blackish) layers, and from 60 to 90 cm rust-coloured small portions occurred here and there. Also in the sandy layer constituting the lowermost part of the section (the core was broken in this layer when

drawn up) the soil was rust-coloured. Below 65 cm very loose clayey silt.

The amounts of extractable metallic cations showed, as in biotope 7A, considerable variations due to the granulometric composition of the soil, but the figures for the percentage of neutralization were even and about the same as in all other samples from Furen.

In comparison with the conditions in biotope 7C there was in the K content a further increase in biotope 7D. At the lower sampled levels noticeably high K values were obtained. Also the amounts of extractable Fe were high here.

The southward increase in the K content was established in summer as well as in winter samplings.

B. *Phragmites communis*

Rhizomes and roots (Fig. 30). In biotope 7A very high frequency of horizontal rhizomes between 12 and 32 cm and extremely high concentration at 20—25 cm. The lowest noted rhizome at 46 cm. Thick as well as fine (straight, slender) roots occurred down to at least 80 cm (some thick roots cut off here). A dense felt of fine roots developed in the superficial 10 cm soil layer. The occurrence of fine roots on shoot nodes was dependent on the water depth conditions. At the summer normal water depth of 30 to 35 cm, roots were developed on most of the submerged nodes.

In biotope 7D the vertical distribution of rhizomes and roots was about the same as in 7A. However, the frequency at the different levels was not at all as high. Fine roots occurred down to 90 cm and one thick root was cut off at that level. As a rule no roots were developed on the lower shoot nodes.

Shoot density (Fig. 28 and Table 13). A marked increase in the shoot density took place in 7 A during the investigation period. Irregularities in the quantitative increase were caused by the cleanings carried out outside the sewage outlet as well as by weather and water level differences in different years.

In biotopes 7 B—D considerable variations in the shoot density were recorded from year to year. Without doubt these were in part due to weather conditions during the spring, when the shoots can be damaged by ice and frost.

Flowering time. Fairly great variations occurred; from second week in Aug. (low water conditions) to second week in Sept. In biotopes 7 B—D the flowering began ca. 1 week earlier than in 7 A.

Panicle frequency (Table 13). In biotope 7 A there was an evident tendency of decrease in the panicle frequency during the investigation period. On the other hand, there was an increase in 7 C—D, while 7 B had about the same frequency in all three years of registration.

Further data in Tables 7—10, 12, 14—15.

Lake Salen

With Biotope 8

General Description

56°51'N, 14°34'E. Altitude 142 m a.s.l. Area 22.0 km². Max. depth 6.6 m.

The lake is formed by glacial excavation in the boundary zone between the large eastern granite area and the large western gneiss area of South Sweden (Fig. 5 C). It is divided by a strait into a small northern and a large southern part. In 1932—1936 the water surface was permanently lowered ca. 1.1 m.

Two streams, Lekarydsån and Benestadsbäcken, discharge their water into the northernmost part of Salen. The humus content of the water of the streams is variable and due to this the water colour and the transparency in northern Salen is subject to variations. The content of humus and total iron is higher in Benestadsbäcken than in Lekarydsån. The water in Salen is often turbid from whirled-up sediments.

The northern shallow part, the only one dealt with here, has been heavily polluted by sewage as well as by waste-water from a slaughterhouse. The combination of the lowering of the water level and the pollution has caused a radical change in the limnologic conditions of the northern part of Salen.

Lakewards from the *Phragmites* biotope, i.e., between the mouths of the mentioned streams, the transparency was 60 cm in June 1954, 100 in Aug. 1954, and 80 in Sept. 1955. On the same occasions the water colour was 80, 120, and 80, pH 6.9, 6.6, and 7.0, the specific conductivity, 76, 69, and 100 μ S, and the content of total iron (as determined by the sulphocyanide method) 1.7, 1.3, and 1.8 mg/l.

Broad luxuriant reed-beds of *Equisetum fluvatile*, *Phragmites communis*, *Scirpus lacustris*, and *Typha latifolia* are expanding lakewards. Large stands of *Carex acuta* are also found, and stands of *Scirpus lacustris* occur in the open lake. *Ceratophyllum demersum*, a species not occurring in the lakes of original status within the region, covers large bottom areas in the northeastern part of Salen, where the transparency outside Lekarydsån is higher than in the north-western part outside Benestadsbäcken.

Biotope 8

A. Environment

Situation (Fig. 7). In the northern part of the lake, just outside the railway station of Alvesta.

Physiographic survey. (Fig. 31). The shore line (NNE—SSW direction) was somewhat altered in connection with the railway building. Above the shore is a ca. 20 m broad zone with tall *Salix* bushes followed by the station yard. Due to the bush girdle



Fig. 31. Biotope 8 Salen. Length of measuring stick above water 3 m. Water depth 1 m. — Photo S. Björk 530820.

the biotope was overshadowed in late evening. It was exposed to winds from the east and south, but wave action was hardly noticeable as the macrophyte vegetation in the shallow water outside the biotope was quantitatively very well-developed.

Along the lakeward *Salix* bush margin *Carex acuta* and *Iris pseudacorus* were frequent, but the only other macrophyte species besides *Phragmites communis* occurring in the biotope was *Lemna minor*.

The dry *Phragmites* stems often remained erect for the following vegetation period.

The water (Table 5). During the observation period (1952—1964) water depths from 20 to 90 cm were noted during the vegetation period.

Dependent on the variations in the supply through the streams Lekarydsån and Benestadsbäcken to the lake of humic water with low content of electrolytes and in the discharge of sewage and industrial wastes, the quality of the surface water showed rather great alterations. The great changes in the Na and Cl content were, of course, due to variations in the supply of polluted water.

The bottom (Figs. 32 and 33). Due to the lowering of the water level and as the shore line was moved lakewards

as a result of the filling-in in connection with the railway building, the bottom consists of gyttja down to 3.5 m at the very shore line. Above the consolidated gyttja was a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

- 0—ca. 48 cm Fairly dark brown gyttja. Here and there black portions. The upper 10 cm rather loose.
- ca. 48—136 cm Homogeneous brown solid gyttja.

The bottom surface and the coarse *Phragmites* detritus above it had a brown colour from precipitated iron, and fine roots developed from *Phragmites* shoot nodes as well as the rhizomes also had a brown iron coating.

The amounts of extractable metallic cations and the percentage of neutralization increased downwards. However, the neutralization was only 50 % in the upper part of the section and did not increase to more than ca. 60 % in the lower part. The downward increase in the total amount of metallic cations was especially due to the increase in the concentration of extractable Fe.

B. *Phragmites communis*

Rhizomes and roots (Fig. 33). The highest frequency of horizontal rhizomes occurred between 25 and 60 cm with a maximum at 45 cm. Fine roots, emanating from thick ones were found down to 120 cm. They had the straight and slender habitus typical of *Phragmites* roots growing in gyttja. A fairly well-developed fine root felt was found down to ca. 20 cm. Most of the shoots were provided with bushy fine roots on 2 to 5 of the lower nodes. (Dead *Equisetum* rhizomes and roots occurred at ca. 50 cm.)

Shoot density. Ca. 90 (70—117).

Flowering time. The panicles were developed as early as in the end

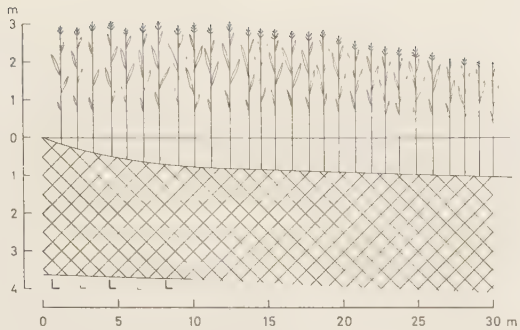


Fig. 32. Lake Salen. Stratigraphic section through biotope 8.

of July, and came into full flower in the second to third week in Aug.

Panicle frequency. Ca. 70 % (48—98).

Further data in Tables 7—10, 12, 14—15.

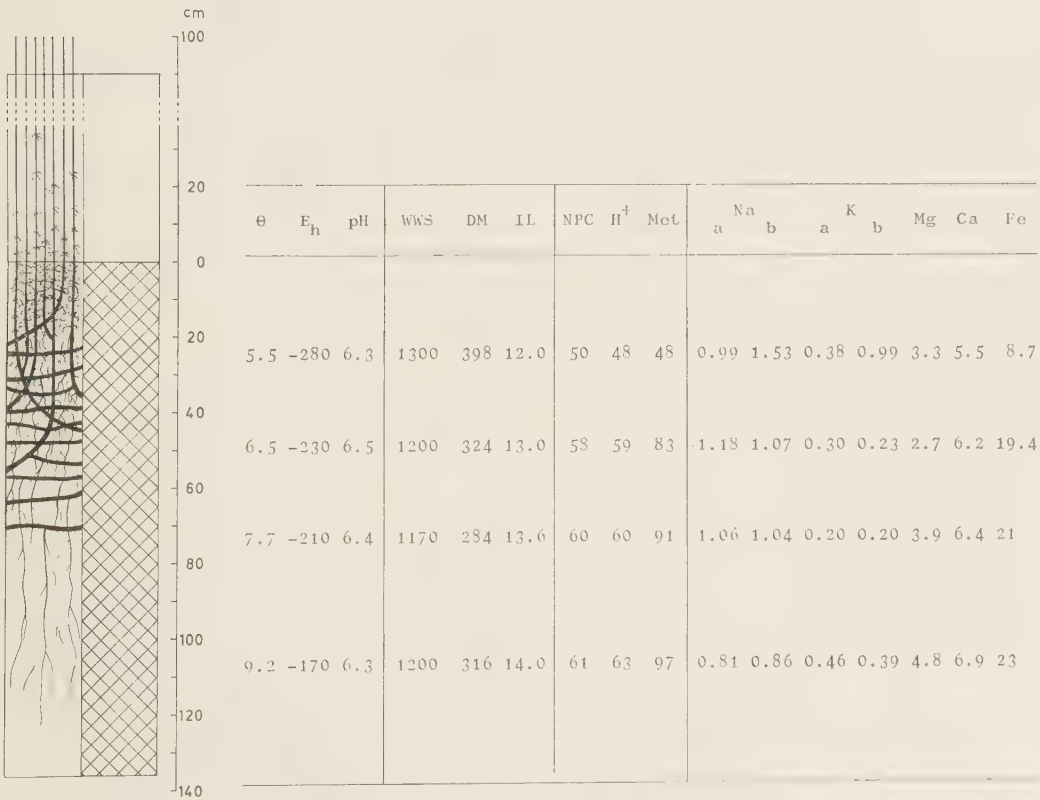


Fig. 33. Biotope 8 Salen 631130. Vertical section and soil analyses.



Fig. 34. Biotope 9 B Trummen. — Photo S. Björk 660903.

Lake Trummen

With Biotopes 9 A—B

General Description

56°52'N, 14°50'E. Altitude 161 m a.s.l. Area 1.2 km². Max. depth 2 m.

A brief summary of the limnologic conditions and the post-glacial development has recently been given by BJÖRK & DIGERFELDT (1965). Earlier investigations in the lake are also referred to in that paper.

For many years the lake was heavily polluted by sewage and industrial wastes. This has resulted in the development of vigorous prolonged water blooms (*Anabaena*, *Microcystis*) during the summer (THUNMARK 1945 a, BJÖRK & DIGERFELDT op.c.), and the turbidity of the water is often very high as the superficial sediments are also easily whirled up. The transparency is therefore, during the summer, often as low as 20 cm.

Luxuriant large stands of *Equisetum fluviatile*, *Phragmites communis*, *Scirpus lacustris*, and *Typha latifolia* are expanding lakewards from broad littoral reed-beds. Plaur formation occurs (BJÖRK & DIGERFELDT op.c.). Overgrown littoral areas have been filled in with wastes, stone and soil. However, as a method of restoring a shore line this mode of action is abortive because the gyttja is pushed upwards in front of the

filling by the pressure of it on the sediments. From these shallow bottom areas (here and there the bottom has become emerged outside the filling) the hyperhydate vegetation is more rapidly expanding further lakewards than before the filling-in was begun.

Biotopes 9 A—B

A. Environment

Situation (Fig. 7). In the north-western bay, outside the St. Sigfrid hospital.

Physiographic survey (Fig. 34). When the investigations were started in 1951, the original shore line (E—W direction) still constituted the limitation of the bay, which is surrounded by a large park with scattered trees. The biotope, 9A, was overshadowed only in the very early morning and late afternoon. It was sheltered against winds and no wave action was noticeable.

The northern part of the bay was at the beginning of the investigation overgrown by hyperhydrites, viz., closest to the shore by a ca. 12 m broad dense *Typha latifolia* stand and then by a homogeneous *Phragmites* reed-bed with a breadth of ca. 65 m (Fig. 35). Lakewards this was followed by *Equisetum fluviatile* and *Scirpus lacustris* stands, partly developed as plaurs.

However, from the middle of the fifties,



Fig. 35. Lake Trummen 530902. Stratigraphic section through biotope 9A.

the northern part of the bay has successively been filled in and in 1964 the shore line was situated ca. 70 m south of the original one. At the same time as the bay was filled in the hyperhydate vegetation advanced lakewards.

In 1951—1954 and 1956 the investigated biotope, 9A, was situated between 15 and 20 m from the original shore line, while biotope 9B, investigated in 1962—1964, was situated 75—80 m from that line, i.e., ca. 15 m outside the end of the stratigraphic section shown in Fig. 35 and in the outer part of the lakewards expanding *Phragmites* stand. The vast *Equisetum fluviatile* stand occurring here at the beginning of the investigation has in part been overgrown by *Phragmites*. The exposition of biotope 9B was about the same as of 9A.

In biotope 9A the only macrophyte species beside *Phragmites communis* was *Lemna minor*, which often had a high frequency. In biotope 9B *Lemna minor*, *Riccia fluitans*, and *Ricciocarpus natans* were very common, the water surface often being totally covered by these spirodelids.

The dry *Phragmites* stems often remained erect for the following vegetation period.

The water (Table 5). In 9A the noted water depths varied from 0 to 50 cm during the vegetation period. Surface water was sampled only once, viz., in Aug. 1956. The specific conductivity was then 230 μ S, pH 6.7, water colour 60, and the oxygen saturation 22 %.

In 9B the noted water depths varied from 0 to 40 cm. The highest available value for the specific conductivity of the surface water is 200 μ S (Sept. 1962).

but mostly lower conductivity values were obtained. The concentration of K was considerable.

The bottom (Figs. 35 and 36). According to the local inhabitants the bay at the beginning of the 20th century had a pure sandy bottom along the shore. Due to the pollution of the lake the bay was overgrown by hyperhydrites and a rapid accumulation of organic matter has taken place. In 1953 when the stratigraphic section in Fig. 35 was made, the water depth at summer normal water level was only 5—10 cm.

Stratigraphy in 9B:

- 0—ca. 40 cm Dense tough felt of dead *Equisetum* rhizomes and roots in loose gyttja, which in the upper half was dark brown and in the lower half light beige-brown.
- ca. 40—142 cm Dark brown coarse gyttja, in the upper part loose. Down to ca. 70 cm rich in drift material. Also at this level a few *Equisetum* roots. Masses of dead unidentified slender radicles.
- 142—150 cm Olive-green clay gyttja with some gravel and sand.

The two upper sampled levels, both in the layer with very high frequency of dead *Equisetum* rhizomes and roots,

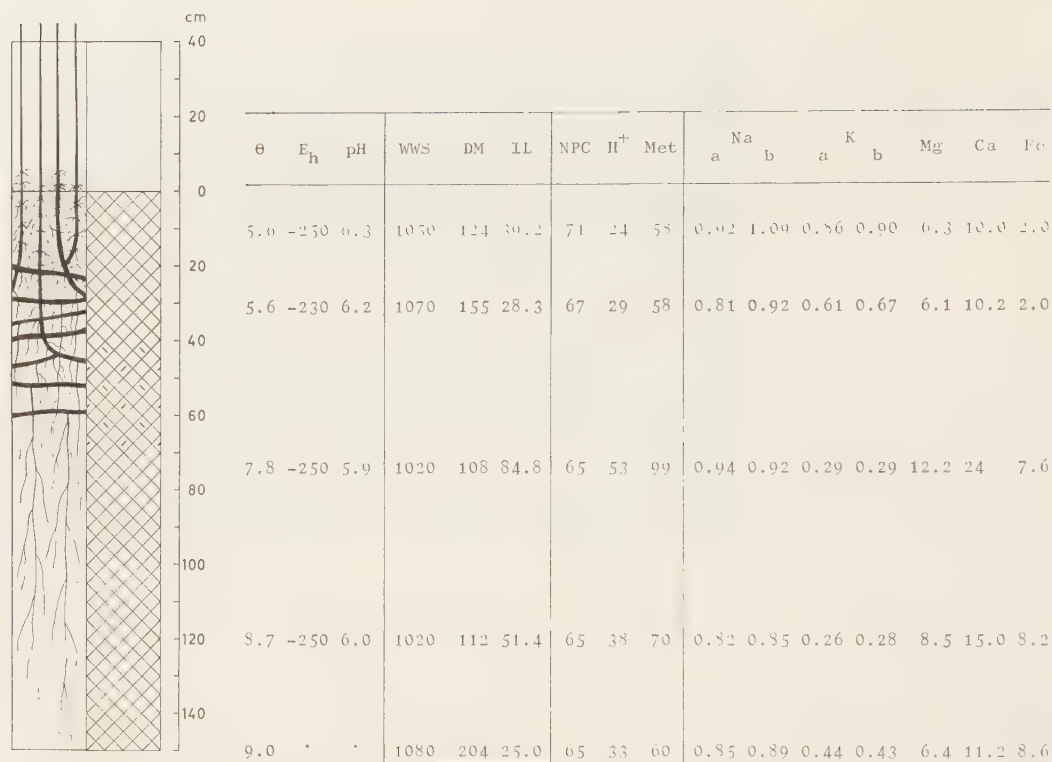


Fig. 36. Biotope 9 B Trummen 631202. Vertical section and soil analyses.

deviated from the underlying coarse detritus gyttja (partly of drift gyttja character) in having lower total amount of extractable metallic cations, but in spite of this slightly higher percentage of neutralization. Furthermore, it contained lower amounts of extractable Mg, Ca, and Fe, but had 2 to 3 times as much extractable K as the underlying soil.

B. *Phragmites communis*

Rhizomes and roots (Figs. 35 and 36). In 9A the *Phragmites* rhizome and root system penetrated the whole organogenic layer down to the minerogenic soil.

In 9B the main part of the horizontal rhizomes was found between 30 and

40 cm. However, rhizomes occurred down to at least 60 cm. Thick as well as fine roots were characteristically slender. Fine roots were found down into the soil with clay gyttja appearance. The highest frequency of fine roots occurred in the superficial 20 cm gyttja layer. Only one to two shoot nodes were provided with fine roots.

Shoot density. In 9A ca. 50 (27—75), in 9B ca. 30 (shoot density records only from 1964).

Flowering time. In both biotopes the panicles came into full flower from the last week in Aug. to the second week in Sept.

Panicle frequency. In both biotopes ca. 85 %.

Further data in Tables 7—10, 12, 14—15.

Survey of the Analyses

In intact status the oligotrophic Ane-boda region probably showed a fairly great homogeneity in the qualitative composition and the quantitative development of the limnic vegetation. In recent times the influence by man on the lakes has brought about considerable changes in these respects. Under the new environmental conditions macrophyte species such as *Equisetum fluviatile*, *Phragmites communis*, *Scirpus lacustris*, and *Typha latifolia* have shown a considerable quantitative increase in lowered and polluted lakes. A rich quantitative development of one or more of the species *Ceratophyllum demersum*, *Lemna minor*, *Riccia fluitans* and *Ricciocarpus natans* can now be found in auxotrophicated lakes. In still more or less intact lakes neither of these species is ever found in mass development.

The biotopes 1—9 were selected in order to illustrate the environmental conditions and the development of *Phragmites* partly in biotopes in as intact status as possible and partly in biotopes affected by human activity. Biotopes 1, 1 A—B, and 2 Fiolen, 3 Stråken, and 5—6 Helgasjön may be considered relatively intact (as for the changes in the surface water quality in Helgasjön in recent times see pp. 46—47). The conditions in the biotopes 4 Stråken, 7 A—D Furen, 8 Salen, and 9 A—B Trummen are due to lowering and/or pollution (mainly by sewage) and definitely deviating from those in the intact ones. The guiding principle for the comparisons in this survey has been to show the differences between the intact and the auxotrophicated biotopes.

A. Environment

In the intact shallow water biotopes *Phragmites* was mostly intermingled with single shoots and individuals of above all *Eleocharis palustris*, *Equisetum fluviatile*, *Isoëtes lacustris*, *Juncus bulbosus*, *Littorella uniflora*, *Lobelia dortmanna*, and *Ranunculus flammula* v. *reptans*. In biotope 2 Fiolen there was a dense isoetid carpet.

In the auxotrophicated biotopes 4 Stråken, 7 A Furen, 8 Salen, and 9 Trummen the *Phragmites* stands were intermingled with *Lemna minor* and in 9 Trummen also *Riccia fluitans* and *Ricciocarpus natans* were frequent. Isoetids still occurred in 7 B—D Furen.

The greatest water depth at summer normal water level was not greater than about 50 cm in any of the biotopes except 2 Fiolen where it was ca. 130 cm (cf. also the outer part of the section through biotope 5 Helgasjön).

There was a good exchange of surface water (analyses in Tables 5—6) in the intact biotopes with sparse reed-beds. Therefore, the changes in the water quality followed those in the superficial layer of the open lake and were comparatively small. In the dense *Phragmites* stands in the auxotrophicated biotopes the water quality was much more variable. This was due mainly to water level fluctuations accompanied by variations in the exchange of water as well as in fluctuations in sewage supply.

Water colour values between 5 and 10 were obtained in the deep water biotope 2 Fiolen where the light conditions at the bottom were good. In the shallow water biotopes the highest co-

lour (90 mg Pt/l) was found in 8 Salen.

In the Fiolen biotopes, the most intact of all from the Aneboda region, the specific conductivity was just below 50 μS , in biotope 3 Stråken it was mostly just above 50 and in Helgasjön, polluted by sulphite waste water, conductivities from 60 to 90 μS were obtained.

Conductivity values of about 100 to 200 μS were mostly obtained in the auxotrophicated biotopes, in 7 A Furen occasionally as high as ca. 1000 μS (Table 6).

For the most part the pH value was lower than 7.0 in all biotopes during the vegetation period. Values higher than 7.0 were found in 1—2 Fiolen and also in the polluted biotope 7 A Furen. The lowest value, viz., 6.3, was obtained in 8 Salen.

The content of K and other analysed elements was constantly higher in the auxotrophicated biotopes than in the intact ones. In 4 Stråken and 7 A Furen, both situated within locally auxotrophicated shore reaches, the variations in the concentration of K as well as of Na, Cl, etc. were considerable.

The quality of interstitial water is exemplified mainly from 2 Fiolen and 3—4 Stråken (Table 5).

The figures from Fiolen illustrate the conditions in a gyttja section. The differences in water quality between the sampled layers were fairly small. The specific conductivity was about two and the K content about three times that of the surface water. The increase in Mg was relatively greater than that of Ca. Down to ca. 30 cm, i.e., the superficial soil layer with highest concentration of living plant roots (of *Phragmites* and especially of isoetids), the concentration

of Cl was lower than in the surface water.

In biotope 3 Stråken interstitial water was sampled in the superficial layer of the hard Archaean moraine, one of the characteristic bottom types of the region. The specific conductivity was about four times that of the surface water which was due to increases in the concentrations of Ca and Mg as well as in the alkalinity. On the other hand, the concentrations of K and Cl were about the same in surface as well as in interstitial water.

In the auxotrophicated biotope 4 Stråken the specific conductivity of interstitial water from the superficial soil layer (low water level, relatively great supply of sewage) was nearly ten times that characteristic of the surface water of the open lake. In this biotope above all Na and Cl as well as the alkalinity showed the greatest increase. However, also the increase of K was considerable when compared with the conditions in biotope 3. On the other hand, the increases of Mg and Ca were fairly slight.

The bottom analyses are exemplified in the Figs. 11, 15, 19, 21, 23, 26, 30, 33 and 36. In this survey the organogenic and minerogenic soils are treated apart and mutually compared with respect to the amounts of extractable metallic cations and the percentage of neutralization.

Among the minerogenic soils the sand in the 5—6 Helgasjön biotopes had the lowest amounts of extractable metallic cations, viz., ca. 20—30 meq/l. Higher amounts were obtained here from sand intermingled with organic matter. The corresponding value for the hard Archaean moraine in 3 Stråken was about

40 and for 1 Fiolen about 70 meq/l. In the washed layers the amount was lower and in the layers containing precipitated iron it was relatively higher. Most sampled layers in the fine-grained minerogenic soils in 7 A—D Furen had ca. 100 or more than 100 meq/l. The highest amounts were found in the layers with the greatest clay content.

Also the gyttja soils showed considerable variations with respect to the amount of extractable metallic cations. 50 to 100 meq/l were obtained in 8 Salen and 9 B Trummen (the decrease in the superficial layer may be caused by the uptake by *Equisetum* and *Phragmites* as well as from some gyttja types in 2 Fiolen. However, from the *Nostoc* gyttja in Fiolen the greatest values from the region, viz., ca. 200 meq/l were obtained. In the stratigraphically complicated section from 4 Stråken the figures varied from 24 in a sandy layer to 83 meq/l in a drift gyttja layer.

Broadly speaking, the percentage of neutralization of the minerogenic soils was greater than that of the organogenic ones. Thus it was 62—77 % in 5—6 Helgasjön (sand), 69—86 % in 3 Stråken, and 76—90 % in 1 Fiolen (in both biotopes Archaean moraine). The highest figures, viz., 85—92 %, were found in Furen, where all sampled layers showed values within this range. From 4 Stråken values from 50 (gravelly sand with drift material) to 89 % (silty fine sand) were obtained.

On the other hand, the lowest values for percentage of neutralization were obtained from the gyttja soils in 8 Salen (50—60 %, pH 6.3—6.5) and 9 B Trummen (ca. 65 %, pH 5.9—6.3). Only the

Nostoc gyttja in Fiolen had values of about 85 % (pH 6.6), while the other gyttja types in this biotope had about 70 % (pH 6.0—6.6).

The greatest amount of extractable Na (more than 3 mmol/l) was found in the superficial layer in the auxotrophicated biotope 7 A Furen. In all other biotopes the Na content was ca. 0.5—1.0 mmol/l except in 7 A—D Furen, where values up to ca. 2 mmol/l were obtained.

Also the highest figures for extractable K (up to 13 mmol/l) were obtained from the fine-grained soils in the Furen biotopes. As low concentrations of K as 0.2—0.3 mmol/l were found in sandy layers with drift material in 4 Stråken, in the sandy Helgasjön soils and in some gyttja layers in 8 Salen and 9 B Trummen. In other soils the K content was mostly about 0.6—1.0 mmol/l.

The fine-grained Furen soils, the unwashed moraine in 1 Fiolen and some of the soils in the 4 Stråken section contained the greatest amounts of Mg and Ca. The different gyttja types in 9 B Trummen were also relatively rich in these elements. On the other hand, the gyttja in 2 Fiolen and 8 Salen as well as the sand in 5—6 Helgasjön were relatively poor in Mg and Ca.

On equivalent basis the Ca/Mg quotient was 1—2 in nearly all minerogenic soils as well as in the gyttja in 8 Salen and 9 B Trummen. In most gyttja types in 2 Fiolen quotients < 1 were obtained.

The gyttja in 2 Fiolen contained great amounts of extractable Fe and also the gyttja in 8 Salen and some of the minerogenic soils in 7 A—D Furen were rich in iron.

B. *Phragmites communis*

The polyploid level of all investigated *Phragmites* clones was tetraploid (Table 7).

In none of the investigated clones was the percentage of apparently morphologically good pollen lower than 80 % (Table 7). The early flowering clone in 8 Salen had the highest value, viz., 95 %.

The mean diameter of the pollen from most clones was between 26 and 28 μm (Table 8). No regular size differences between clones in intact and clones in auxotrophicated biotopes were established. Pollen grains larger than 28 μm were found in samples from the biotopes 1 and 1 A—B Fiolen, from sites outside biotope 5 Helgasjön, and from biotope 8 Salen. However, in all these samples there was an excess of grains from the top part of the panicles.

The rhizosphere had the smallest vertical extension in hard minerogenic soils and the widest in gyttja and loose sandy and silty soils.

The panicle shoots in the intact shallow water biotopes 1, 1 A—B, 3, and 5 were smaller than 1.5 m (Fig. 37, Table 10). Shoots with a length of ca. 2 m occurred partly in 6 Helgasjön (shallow water) and partly in 2 Fiolen (deep water). In the auxotrophicated biotopes the length of the panicle shoots was ca. 2.5 m in 4 Stråken and more than 3 m in 8 Salen and 9 A—B Trummen. In the Furen biotopes the longest shoots occurred closest to the sewage outlet.

Characteristic of *Phragmites* in this region is the increase of the shoot dimensions as it grows lakewards in successively deeper water and at the same

time from minerogenic (moraine and sandy sediments) towards areas with fine minerogenic fractions, gyttja soils or mixed minerogenic and gyttja soils. These conditions are demonstrated by the section through biotope 5 Helgasjön (Fig. 24, Table 11) and are also obvious from the comparison between biotopes 1 and 2 Fiolen (Table 10).

In comparison with the conditions in the regio-characteristic intact biotopes there was in the auxotrophicated ones an evident increase in number and dimensions of the leaves and internodes (Table 10). This increase was also reflected in the shoot weight analyses (Table 12).

In the intact shallow water biotopes 1 and 1 A—B Fiolen, 3 Stråken, and 5 Helgasjön the leaf area of the grown-out shoots with panicles and concerning 5 Helgasjön shoots without panicles was only about 1.0—1.8 dm^2 . In 2 Fiolen and 6 Helgasjön the area was about twice as large. With the exception of 7 A—D Furen the shoots from auxotrophicated biotopes had considerably larger leaf areas per panicle shoot, viz., from ca. 7 to 15 dm^2 . In 7 A Furen, i.e., nearest the sewage outlet, the leaf area per panicle shoot was ca. 3 dm^2 , while in 7 B—D it was about 1.0—1.5 dm^2 .

The length of the stomatal guard-cells of the middle leaves was less than 25 μm and the stomata density exceeded 1000 per mm^2 in all biotopes except 7 A (Table 9).

In the intact biotopes the shoot density varied from ca. 4 (2 Fiolen) to 25 with the exception of 6 Helgasjön where it was ca. 45. In the auxotrophicated biotopes the density was within the range 30 (9 A—B Trummen) to 150 (7 A Furen). In the fairly young *Phragmites* stand with biotopes 7 A—D in



Fig. 37. Panicles and shoots from biotopes in the Aneboda region. Biotopes represented by panicles from different years: 3 (1961 and 1964), 8 (1955 and 1964) and 9 B (1962 and 1966). The shoot from 5 A represents the outer margin of the reed-bed shown in Figs. 22 and 24.

TABLE 5. Water analyses.

Biotope	Date	SW IWS	Sampling level cm	Water, depth cm	θ °C	Col Pt mg/l	Sp.cond. μS	pH	Na	K	Mg	Ca	Fe	Cl	P	Alk μeq/l
1 Fiolen	630720	SW	0	30	18.7	10	46	6.8	150	22	50	90	-	160	-	50
	631201	SW	0	50	2.8	10	48	6.4	160	27	50	90	0.8	150	0.4	42
	630720	SW	0	130	17.2	10	46	6.8	150	21	50	90	-	150	-	50
	631129	SW	0	140	2.9	10	47	6.5	150	26	40	90	0.8	150	0.5	44
2 Fiolen	640907	IWS	-9	-	-	70	97	7.5	300	64	290	140	130	110	-	-
	-28	-	-	-	-	-	98	6.8	310	78	190	130	80	200	-	-
	-79	-	-	-	-	100	76	6.9	290	77	140	100	150	215	-	-
	-90	-	-	-	-	120	80	6.7	300	75	140	90	130	230	-	-
3 Stråken	631201	SW	0	75	2.5	60	52	6.2	170	26	50	100	6	165	0.7	46
	640908	SW	0	15	15.5	15	54	6.8	180	25	30	120	2	170	-	94
	640908	IWP	-17	35	15.5	25	230	6.4	210	29	460	620	14	185	-	1940
	640908	IWP	-2	10	12.5	440	470	6.5	2190	130	140	360	16	1610	-	1460
4 Stråken	631129	SW	0	84	2.7	70	54	6.2	170	27	50	110	7	175	1.2	56
	640908	IWP	-2	10	12.5	440	470	6.5	2190	130	140	360	16	1610	-	1460
	631202	SW	0	90	3.4	20	80	6.7	230	29	80	170	2	275	0.6	64
	640730	SW	0	25	20.2	15	87	6.8	240	27	80	200	2	305	-	74
5 Helgasjön	631202	SW	0	82	3.0	20	81	6.7	230	28	70	180	2	275	0.7	60
	640730	SW	0	25	20.2	15	89	6.7	240	28	70	200	2	305	-	74
	631202	SW	0	63	-	55	84	6.6	240	46	100	170	5	260	1.0	124
	640814	SW	0	3	15.6	90	770	7.2	3330	600	220	680	7	1870	-	4970
7A Furen	631202	SW	0	65	-	55	82	6.6	230	47	110	160	5	260	0.7	132
	640814	SW	0	3	16.8	20	83	6.8	250	45	70	170	1	280	-	88
	631130	SW	0	90	3.3	80	69	6.1	210	40	60	140	10	215	0.9	64
	640730	SW	0	25	18.2	90	110	6.3	500	47	80	170	28	475	-	178
8 Salen	631202	SW	0	40	1.4	50	140	6.9	350	110	130	370	6	390	2.6	488
	640730	SW	0	12	16.0	55	170	6.5	350	200	170	520	10	365	-	1220

TABLE 6. Water analyses from Lake Furen.

Biotope	Date	Sp.cond. μS	pH	Col Pt mg/l	(O ₂) g
7 A	June 1954	94	6.7	40	59
	Aug. 1954	100	6.6	80	57
	July 1955	1080	7.5	280	48
	Sept. 1962	99	6.5	-	-
7 C	Dec. 1963	84	6.6	55	-
	Aug. 1964	770	7.2	90	-
	June 1954	75	7.0	40	100
	Aug. 1954	76	6.3	60	82
9 B Trummen	July 1955	73	7.5	40	110
	Sept. 1962	72	7.0	-	-
	Dec. 1963	82	6.6	55	-
	Aug. 1964	83	6.8	20	-

TABLE 7. Polyploid level and pollen quality.

Biotope	Polyploid level	Pollen quality (F) (D)
1 Fiolen	4x	87
2 Fiolen	4x	80
3 Stråken	4x	82
4 Stråken	4x	-
5 Helgasjön	4x	-
6 Helgasjön	4x	-
7 A-D Furen	4x	80-90
8 Salen	4x	95
9 B Trummen	4x	90

TABLE 9. Biometric analyses of stomata.

Biotope	Date	Shoot type	Shoot length cm	No.	Insertion level cm	Leaf			Guard-cell length				Stomata density		Leaf area x stomata density
						Length cm	Breadth mm	Area cm ²	n	m	μm	s	n/mm ²	m/mm ²	
1 Fiolen	630920	PS	127	2	104	29	17	29	50	21.4	0.15	1.09	10	1120	33
	630920	PS	124	4	110	25	12	17	50	20.6	0.21	1.47	10	1160	20
	630920	PS	124	6	115	18	7	6	50	20.0	0.15	1.08	10	1050	6
	630920	PS	124	4	102	27	12	18	50	21.8	0.17	1.22	10	1180	21
2 Fiolen	660901	WPS	213	1	170	32	27	58	50	25.1	0.28	1.98	10	930	54
	660901	WPS	208	5	193	36	23	44	50	24.4	0.21	1.48	10	1050	46
	660901	WPS	208	9	213	30	17	26	50	23.2	0.19	1.34	10	1120	29
	660901	WPS	208	5	192	33	21	36	50	24.3	0.24	1.67	10	1010	36
3 Stråken	660902	PS	119	1	79	23	15	19	50	24.6	0.23	1.62	10	1070	20
	660902	PS	119	4	97	23	15	19	50	21.7	0.16	1.16	10	1260	24
	660902	PS	119	7	106	17	9	10	50	21.1	0.15	1.05	10	1460	15
	660902	PS	119	4	96	21	13	17	50	22.1	0.16	1.16	10	1270	22
4 Stråken	660831	PS	274	1	145	35	27	59	50	25.3	0.23	1.60	10	770	45
	660831	PS	255	5	198	44	30	65	50	22.9	0.26	1.85	10	1320	86
	660831	PS	255	10	244	42	25	51	50	22.1	0.21	1.50	10	1280	65
	660831	PS	255	5	198	46	30	68	50	22.3	0.22	1.52	10	1330	90
6 Helgasjön	660903	PS	275	1	173	36	28	61	50	25.2	0.27	1.91	10	980	60
	660903	PS	247	5	234	44	28	57	50	23.2	0.27	1.94	10	1210	69
	660903	PS	247	8	260	35	21	39	50	22.2	0.20	1.45	10	1280	50
	660903	PS	247	5	211	37	26	52	50	24.2	0.28	1.95	10	1140	59
7A Furen	660903	PS	234	1	112	25	29	47	50	29.0	0.31	2.21	10	680	32
	660903	PS	234	5	170	41	35	77	50	25.5	0.32	2.26	10	880	68
	660903	PS	224	9	206	36	23	44	50	23.3	0.23	1.66	10	1110	49
	660903	PS	224	5	153	39	34	76	50	26.5	0.25	1.78	10	990	75
7C Furen	660903	PS	165	1	96	26	20	31	50	25.9	0.22	1.57	10	800	25
	660903	PS	165	6	143	35	20	37	50	22.7	0.26	1.84	10	1270	47
	660903	PS	166	3	124	31	20	35	45	24.3	0.32	2.14	10	1050	37
	660903	PS	166	1	232	43	37	78	50	24.9	0.21	1.49	10	980	76
8 Salen	630920	PS	307	4	277	44	34	85	50	23.5	0.19	1.34	10	1120	95
	630920	PS	317	7	294	41	26	53	50	23.0	0.17	1.18	10	1220	65
	630920	PS	317	4	274	44	32	78	50	23.6	0.21	1.46	10	1120	87
	630920	PS	317	11	286	52	45	116	50	25.2	0.20	1.44	10	1000	116
9 Trummen	660903	PS	324	6	242	50	42	111	50	22.8	0.21	1.49	10	1420	158
	660903	PS	317	5	234	52	50	88	50	22.5	0.21	1.48	10	1310	115
	660903	PS	317	5	234	52	50	140	50	23.9	0.25	1.74	10	1290	181

TABLE 8. Biometric analyses of pollen.

Biotope	Date	Pollen diameter μm						Pollen volume 100 μl		
		n	m	e	s	min	max	min	m	max
1 Fiolen	550926	675	27.1	0.06	1.54	18.0	31.5	31	105	165
	570913	225	27.6	0.11	31.58	10.8	31.5	41	110	165
	630920	225	29.4	0.11	1.63	25.9	32.9	92	133	188
	620921 ^{*2}	225	29.4	0.11	1.61	25.2	33.6	84	133	199
1A Fiolen	620921 ^{*2}	225	28.7	0.10	1.43	25.2	32.2	84	125	175
1B Fiolen	610910	225	27.0	0.10	1.53	23.1	31.5	65	103	165
3 Stråken	640909	225	26.0	0.11	1.70	22.4	30.8	59	92	153
4 Stråken	550913	225	26.9	0.09	1.29	23.8	30.1	71	103	144
Helgasjön ^{*1}	610911	134	30.3	0.17	1.95	25.2	35.0	84	147	225
6 Helgasjön	610911	130	29.3	0.11	1.27	26.6	32.2	99	133	175
6 Helgasjön	610911	225	27.4	0.09	1.35	24.5	30.8	78	108	153
7A Furen	640814	225	27.3	0.09	1.42	23.8	30.8	71	108	153
7B Furen	640814	225	27.3	0.08	1.16	25.2	30.8	84	108	153
7C Furen	640814	225	27.2	0.08	1.22	24.5	30.8	78	105	153
7D Furen	640814	225	27.5	0.09	1.33	23.8	30.8	71	110	153
8 Salen	610810 ^{*2}	225	29.7	0.12	1.79	24.5	34.3	78	139	213
8 Salen	640730	225	30.4	0.12	1.82	25.2	35.0	84	147	225
9A Trummen	560830	225	26.2	0.10	1.50	22.4	30.1	59	94	144
9B Trummen	640909	225	26.8	0.10	1.47	23.1	30.8	65	101	153

*1 = panicles sampled lakewards from biotope 5, in top flowering.

*2 = panicles in top flowering.

TABLE 10. Biometric analyses of shoots.

TABLE 11. Biometric analyses of shoots from sites along a horizontal section through biotope 5 Helgasjön (see fig. in description of biotope). Sampling method 2, Aug. 10, 1955. 16 shoots per sampling square (4 m²). Weights in g/WPS.

Sam- pling square	Water depth cm	Leaves		Weights		Total		Shoot length cm			Dist. base-1st green leaf, cm			Diameter of base internode mm			Diameter of internode at 1st green leaf, mm			Number of internodes per shoot			Internode length cm			Number of green leaves per shoot			Leaf length cm			Leaf breadth mm			Leaf area per shoot dm ²	Shoots per m ² PS/WPS			
		DM	AW	DM	AW	DM	AW	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	n	m	e	s	n	m	e	s	n	m	e	s					
A	29	0.85	0.06	3.41	0.12	4.25	0.18	120	6.58	26.3	86	2.42	9.66	4.5	0.17	0.69	2.9	0.19	0.75	13.9	0.58	2.31	222	8.3	0.32	4.78	7.4	0.49	1.96	119	22.0	0.49	5.33	119	14.5	0.36	3.91	1.54	0/31
B	42	0.72	0.07	3.58	0.11	4.31	0.18	115	7.62	30.5	88	3.84	15.4	3.7	0.27	1.06	2.7	0.19	0.77	13.1	0.57	2.29	209	8.3	0.41	5.95	6.7	0.43	1.70	107	21.5	0.55	5.66	107	14.6	0.38	3.95	1.35	0/16
C	53	0.56	0.06	3.00	0.11	3.56	0.17	128	5.42	21.7	103	3.49	14.0	4.1	0.19	0.78	2.8	0.13	0.52	13.2	0.49	1.97	211	9.1	0.42	6.17	6.4	0.38	1.50	103	20.8	0.46	4.70	103	13.6	0.34	3.42	1.18	0/18
D	91	1.15	0.12	5.94	0.23	7.09	0.35	183	5.23	20.9	139	2.90	11.6	5.3	0.33	1.30	3.3	0.12	0.48	16.4	0.41	1.63	262	10.7	0.48	7.79	8.6	0.27	1.09	137	24.3	0.42	4.95	137	16.4	0.33	3.84	2.11	1/12
E	160	2.00	0.18	9.94	0.49	11.94	0.67	248	3.90	15.6	201	3.17	12.7	6.2	0.22	0.88	4.3	0.12	0.49	18.4	0.41	1.63	294	12.9	0.58	10.0	9.1	0.37	1.48	145	29.8	0.40	4.84	145	22.2	0.32	3.82	3.60	.

TABLE 12. Shoot weights (g/shoot).

Biotope	Date	Sampling method (no.) and area (m ²)	Number and type of shoots PS/WPS	Panicles		Leaves		Rest		Total	
				DM	AW	DM	AW	DM	AW	DM	AW
1 Fiolen	540819	2/16	45/19 = 64	0.09	0.004	0.52	0.04	1.8	0.08	2.4	0.11
	560903	2/16	44/20 = 64	0.11	0.008	0.45	0.03	2.1	0.08	2.7	0.12
	570913	2/16	42/22 = 64	0.17	0.009	0.45	0.03	1.9	0.07	2.4	0.11
2 Fiolen	560903	2/16	0/64 = 64	.	.	2.1	0.27	9.9	0.58	12	0.83
	570913	2/16	14/50 = 64	0.04	0.005	2.1	0.25	10	0.58	12	0.83
5 Helgasjön	530812	2/4	0/64 = 64	.	.	0.58	0.06	2.9	0.11	3.5	0.17
6 Helgasjön	530812	2/2	11/21 = 32	0.09	0.006	1.9	0.16	8.2	0.28	10	0.44
7A Furen	560822	2/1	16/0 = 16	1.5	0.08	2.0	0.21	6.3	0.38	9.9	0.69
	610911	2/1	16/0 = 16	1.1	0.06	1.4	0.13	5.4	0.36	8.0	0.55
7B Furen	560822	2/1	16/0 = 16	0.69	0.03	0.94	0.08	3.3	0.17	4.9	0.28
	610911	2/1	16/0 = 16	0.43	0.02	1.0	0.09	2.8	0.21	4.2	0.33
7C Furen	560822	2/1	14/2 = 16	0.25	0.01	0.60	0.05	1.9	0.10	2.8	0.16
	610911	2/1	16/0 = 16	0.69	0.03	0.94	0.08	3.2	0.21	4.8	0.31
7D Furen	560822	2/1	12/4 = 16	0.21	0.008	0.63	0.04	2.2	0.10	3.0	0.15
	610911	2/1	16/0 = 16	0.49	0.02	0.69	0.05	2.5	0.14	3.7	0.21
8 Salen	530820	2/4	63/1 = 64	0.73	0.05	4.3	0.39	17	0.70	22	1.1
9 Trummen	530902	2/4	64/0 = 64	6.4	0.42	9.0	1.0	31	2.1	46	3.5
	560830	2/4	64/0 = 64	4.7	0.25	8.2	0.94	31	1.6	44	2.8

TABLE 13. Shoot density and panicle frequency in Lake Furen.

Bio- tope	Year	Shoot density	Panicle frequency %
7 A	1952	65	.
	1956	97	73
	1961	154	55
	1964	135	46
7 B	1952	60	.
	1956	90	77
	1961	45	78
	1964	82	73
7 C	1952	53	.
	1956	87	36
	1961	73	79
	1964	85	89
7 D	1952	78	.
	1956	60	40
	1961	45	76
	1964	88	86

TABLE 14. Standing crop (g/m²).

Biotope	Date	Shoot type	Shoots per m ²	Panicles			Leaves			Rest			Total			Stand. crop DM
				FW	DM	AW	FW	DM	AW	FW	DM	AW	FW	DM	AW	
1 Fiolen	630920	2 PS	7/0.5*1	1.8/*2	0.7	0.04	14	5.5	0.45	62	24	0.96	78	30	1.45	48
		DS	10.5	.	.	.	7	2.2	0.23	45	16	0.59	51	18	0.82	
		DS	1	.	.	.	.	.	.	.	.	.	.	.	1.4	
1A Fiolen	620921	2 PS	6	1.1	0.5	0.02	8	3.2	0.24	43	15	0.50	52	19	0.76	23
		WPS	3.5	.	.	.	2	0.5	0.04	12	3.4	0.11	14	3.8	0.14	
		DS	0.5	.	.	.	.	.	.	.	.	.	.	.	0.3	
2 Fiolen	620918	8 WPS	3.5	.	.	.	21	7.1	0.75	157	33	1.94	178	40	2.69	40
		PS+WPS	5.6+9.8	.	0.3	0.02	.	6.6	0.63	.	23	1.23	.	30	1.88	
		DS	.	.	.	.	.	.	.	.	.	.	.	.	4.7	
3 Stråken	610910	5 PS+WPS	5.6+9.8	.	0.3	0.02	.	6.6	0.63	.	23	1.23	.	30	1.88	30
		DS	.	.	.	.	.	.	.	.	.	.	.	.	4.7	
		DS	.	.	.	.	.	.	.	.	.	.	.	.	1.1	
	620919	4 PS	0.3	.	.	.	0.5	0.1	0.01	3	1.1	0.04	3.5	25	1.41	26
		WPS	21	.	.	.	20	5.4	0.46	66	19	0.95	86	25	1.41	
		DS	.	.	.	.	.	.	.	.	.	.	.	.	.	
4 Stråken	620919	4 PS	6.5/12.3	8.7/9.6	3.9/3.6	0.23/0.20	211	80	6.2	808	310	10.4	1037	397	16.9	568
		WPS	16.5	.	.	.	120	39	3.1	382	125	4.84	502	164	27.7	
		DS	0.8	.	.	.	2	0.8	0.06	20	6.7	0.21	22	7.4	0.27	
5 Helgasjön	640730	4 WPS	13.8	.	.	.	21	7.3	0.49	88	32	0.84	108	39	1.32	39
		PS	1	0.5	.	.	8	2.8	0.17	34	13	0.39	43	16	0.56	
		WPS	38	.	.	.	179	63	3.82	608	233	5.77	787	295	9.65	
6 Helgasjön	640730	2 PS	1	0.5	.	.	8	2.8	0.17	34	13	0.39	43	16	0.56	311
		WPS	38	.	.	.	179	63	3.82	608	233	5.77	787	295	9.65	
		DS	.	.	.	.	.	.	.	.	.	.	.	.	.	
7A Furen	640814	1 PS	57/5	170/.	57	2.87	340	108	11.5	866	209	14.4	1376	375	28.7	541
		WPS	73	.	.	.	169	52	4.94	376	114	9.02	545	166	14.0	
		DS	14	.	.	.	.	.	.	.	.	.	(25)	.	.	
7B Furen	640814	1 PS	49/11	59/.	22	1.01	109	38	3.09	378	152	8.32	546	212	12.4	226
		WPS	22	.	.	.	7	2.1	0.21	33	13	0.70	40	15	0.91	
		DS	15	.	.	.	.	.	.	.	.	.	(22)	.	.	
7C Furen	640814	1 PS	63/13	70/.	28	1.17	108	37	2.72	496	207	9.27	674	273	13.2	280
		WPS	9	.	.	.	2.3	0.8	0.05	17	6.6	0.31	19	7.4	0.36	
		DS	7	.	.	.	.	.	.	.	.	.	(8)	.	.	
7D Furen	640814	1 PS	57/18	94/.	38	1.64	152	54	4.25	602	268	13.0	848	360	18.9	372
		WPS	13	.	.	.	4.8	1.6	0.16	26	11	0.62	31	12	0.78	
		DS	13	.	.	.	.	.	.	.	.	.	(17)	.	.	
8 Salen	640730	2 PS	41/5.5	75/0.8	24/.	1.31	682	222	14.7	2580	937	25.5	3337	1182	41.5	1782
		WPS	40	.	.	.	397	119	8.1	1556	475	19.6	1916	594	27.7	
		BS	0.5	.	.	.	2	0.6	0.04	39	8.8	0.37	31	4	0.41	
9 Trummen	640909	1 PS	21/6	243/.	109	8.31	570	207	22.6	2057	835	36.7	2870	1152	67.7	1278
		WPS	3	.	.	.	60	20	2.15	235	83	3.65	295	103	5.80	
		BS	1	.	.	.	10	3.6	0.40	43	20	0.88	53	24	1.28	
		DS	5	.	.	.	.	.	.	.	.	.	(203)	.	.	

*1 = shoots with normal panicles/shoots with dry, undeveloped, and deformed panicles. *2 = normal panicles/dry etc. panicles.

TABLE 15. Environmental conditions at samplings, description of samples for sap expression and analyses of whole samples, press-cakes and expressed sap.

Shoot part	Biotope	Shoot type	Sample no.	Date	h	Wind velo- city	Cloudi- ness
---------------	---------	---------------	---------------	------	---	-----------------------	-----------------

Furen there was an increase in the shoot density nearest to the sewage outlet during the observation period (Table 13).

As a rule the panicle frequency was very low, viz., 0—10 %, occasionally up to 20 %, in 2 Fiolen and 5—6 Helgasjön. In 3 Stråken variations from 1 to 40 % were noted in different years while in 1 Fiolen the frequency was fairly constantly about 50 %. In the auxotrophicated biotopes the frequency was mostly considerably higher, viz., 70—90 %. The increase in shoot density in 7 A Furen was accompanied by a decrease in panicle frequency (Table 13).

The greatest difference in flowering time between the clones amounted to about one month. The earliest flowering occurred regularly in 8 Salen and the latest usually in 1 Fiolen. In 2 Fiolen the panicles never reached the stage of flowering.

At about the time of flowering the total leaf area per m^2 (Table 10) was within the range 7—16 dm^2 in the intact

most regio-characteristic shallow-water biotopes 1 and 1 A—B Fiolen, 3 Stråken, and 5 Helgasjön as well as in the deep-water biotope 2 Fiolen, but ca. 100 in the shallow-water biotope 6 Helgasjön. In the auxotrophicated biotopes (except 7 B—D) it varied from ca. 200 dm^2 in 4 Stråken to ca. 770 in 8 Salen. The biotopes 7 B—D, situated some distance from the sewage outlet in Furen, were characterized by fairly small total leaf areas, viz., ca. 60—90 dm^2/m^2 .

The standing crop (Table 14) amounted to 20—50 g in the intact biotopes 1, 1 A—B, 2, 3, and 5, while it was ca. 300 in the — from a regio-limnologic point of view — deviating biotope 6. In Furen the highest figure for standing crop, about 500 g, was found in 7 A. In 7 B—D it was between 200 and 400 g. In the other auxotrophicated biotopes values from ca. 600 (4 Stråken) to ca. 1800 g (8 Salen) were obtained.

The analyses of expressed sap are discussed in the Synthetic Part.

II. Biotopes in the Veden–Tiken–Ängsjön Region

General Description of the Region

Phragmites investigations were carried out in 6 lakes, viz., Rolsmosjön, Linnerydssjön, Veden, Hammaren, Tiken, and Ängsjön (Fig. 38).

Veden, Hammaren, Rolsmosjön, Linnerydssjön, and Ängsjön belong to the watercourse system of the river Ronnebyån, while Tiken is drained by Bräkneån. In reality Veden and Hammaren are enlargements of Ronnebyån. The whole region lies above the highest shore line.

Nearly the whole region belongs to the large granite area of southeastern Sweden.

The lakes Veden, Hammaren, and Ängsjön are situated in areas where the influence of the bedrock on the fertility of the soil is unfavourable, while the lakes Rolsmosjön, Linnerydssjön, and Tiken totally or for the main part belong to areas where the bedrock to some degree has a favourable or a rather favourable influence. The best conditions are found in a strip around Lake Linnerydssjön and the southern part of



Fig. 38. Topographical maps of the areas around the lakes with biotopes 10–17 included in the Veden–Tiken–Ängsjön region. Compare Fig. 4.

Rolsmosjön (compare ATLAS ÖVER SVE-RIGE).

Within a N—S rectangle including the lakes 13 % is designated arable land, i.e., the same percentage as in the Aneboda region. The surface soils of the cultivated areas are moraine sand and moraine fine sand.

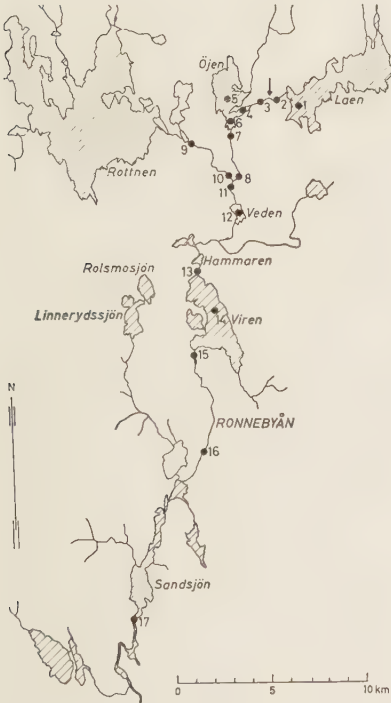
All lakes except Linnerydssjön and Rolsmosjön are situated in areas where forests cover 60—80 % of the total land area. The two mentioned lakes lie at the boundary of an area having a forest cover of 40—60 %.

Ängsjön is the lake least affected by human activity. The water level of Rolsmosjön and Linnerydssjön, which are in

direct connection through a short deepened ditch, has been permanently lowered, and that is the case also in Tiken.

Linnerydssjön and Tiken are recipients of sewage and industrial waste water. Veden as well as Hammaren are via the stream Lesseboån (a tributary of Ronnebyån) polluted by sulphite-mill waste water and sewage from the market town Lessebo. In Fig. 39 some data are presented to give an idea of the pollution situation in this part of Ronnebyån. Fungus slime growth (*Fusarium aquaeductum*) was observed down to Lake Viren.

Climatic characteristics are shown in Figs. 5—6 and 40.



Sta- tion	Tr cm		Col mg Pt/l		KMnO ₄ -cons. mg/l		pH		Sp. cond. µS		Cl µmol/l		PO ₄ -P µg/l		Tot. P µg/l	
	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
1	520	320	25	50	51	68	6.2	5.7	40	46	170	160	1.8		3.6	
2	*	*	25	50	52	67	6.3	5.8	40	46	180	160	2.7		4.4	
3	*	*	40	55	620	510	4.7	4.7	140	150	680	560	86		89	
4	*	*	40	60	580	450	4.7	4.7	85	150	260	620	9.3		27	
5	240	220	70	65	80	75	6.7	6.4	53	52	230	180	2.2		9.3	
6	90	70	40	80	660	470	4.7	4.7	160	140	790	510	1.3		10	
7	*	*	50	70	650	230	4.9	5.7	160	78	760	280	4.9		24	
8	150	130	45	80	440	280	5.5	5.6	100	95	420	370	8.4		21	
9	*	*	*	25	*	49	*	6.3	*	54	*	210	*	*		*
10	>340	>310	20	30	48	52	6.3	6.2	49	54	220	210	0.9		1.8	
11	280	160	30	50	180	130	5.9	5.8	69	70	310	280	1.8		10	
12	250	190	35	50	160	185	5.8	5.6	70	86	310	340	1.8		4.9	
13	*	*	40	65	160	160	5.8	5.6	71	83	340	340	1.8		*	
14	>210	230	40	80	150	170	6.0	5.9	74	82	310	340	14		15	
15	*	*	50	80	140	160	6.1	5.9	78	83	340	340	9.3		10	
16	*	*	50	90	140	160	6.1	5.9	78	83	340	310	12		13	
17	*	*	*	90	*	150	*	6.1	*	80	*	310	*	*		*

Fig. 39. Schematic map of the upper part of the watercourse system of Ronnebyån and water analyses from this area (sampling stations indicated by numbers on the map). Outlet for sewage and industrial waste-water in Lessebo indicated by an arrow. Samplings: a=581028—29; b=610515—16.

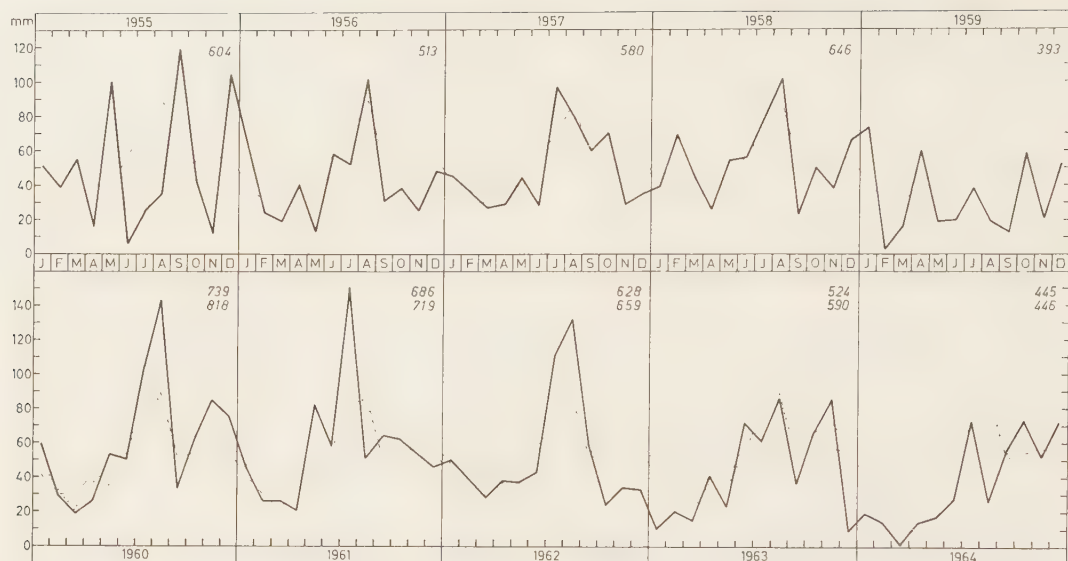


Fig. 40. Precipitation per month in Lessebo (solid line) and monthly mean precipitation for the period 1960–1964 for Mjuamåla, situated 4 km north of Lake Ängsjön (dotted line). Monthly mean precipitation for the international period 1901–1930 for Lessebo indicated by broken line. Top right figures for yearly precipitation in Lessebo (above) and Mjuamåla.

Lake Rolsmosjön

With Biotores 10–11

General Description

56°40'N, 15°10'E. Altitude 136 m a.s.l. Area 0.8 km².

The basin is a shallow moraine depression. The shores are minerogenic.

The water level has been permanently lowered. A well developed shore barricade along parts of the western shore is situated 40–50 m from the present shore line and separated from this by a plane gravelly zone. There is local auxotrophication by sewage in the southeastern part of the lake. Without any doubt the lake is slowly changing its character as a consequence of the lowering of the water level.

The supply of surface water is small. Though the water can have a fairly high plankton turbidity the transparency centrally in the north half of the lake is usually greater than the water depth (ca. 2 m). Water quality data (sampling of pelagic water from the superficial layer in Sept.

1958 and July 1959): Col 3/2, Sp. cond. 68/78 μ S, pH 6.8/6.7, and (O₂)s 96/100 ‰. On the sampling occasion in 1959 the water level was exceptionally low after a period of low precipitation.

In the northern part the hyperhydrate and ephydate vegetation (though in stands over large areas) is rather sparse. In the south bays there are, however, fairly large and dense stands of *Equisetum fluviatile*, *Phragmites communis*, and *Scirpus lacustris*. Also large stands of *Eleocharis palustris* and *Carex rostrata* occur here and there. *Nuphar luteum* and *Potamogeton natans* are the most common ephydate species and *Juncus bulbosus* as well as *Myriophyllum alterniflorum* show the highest frequency among the elodeids. The last-mentioned species occurs over a large part of the lake and reaches the water surface out to a depth of 2.1 m. From a quantitative point of view the isoetids are well developed (dense carpets). The following species were noted: *Isoetes lacustris*, *Littorella uniflora*, *Lobelia dortmanna*, *Pilularia globulifera*, *Ranunculus flammula* v. *reptans*, and *Subularia aquatica*.



Fig. 41. Biotope 10 Rolsmosjön. — Photo S. Björk 640801.

Biotope 10

A. Environment

Situation (Fig. 38). Outside a small level tongue of land protruding from the west shore ca. 200 m south of the north end of the lake.

Physiographic survey (Fig. 41). Above the shore is a ca. 30 m broad plane zone without trees up to a low icepressed dam. This zone is covered by *Carex rostrata*, *Molinia coerulea*, *Myrica gale*, and *Betula* bushes. *Utricularia minor* was common in the littoral fen and iron ochre formations were frequent. Approximately 15—20 m further landwards is the high old barricade. The zone between the dam and the barricade is overgrown by *Picea*, *Pinus* and *Betula*.

The biotope is exposed to winds from all directions, but the wave action is rather weak.

The *Phragmites* stand is intermingled with the following plant species: *Eleocharis palustris*, *Juncus bulbosus*, *Littorella uniflora*, *Lobelia dortmanna*, *Myriophyllum alterniflorum*, *Pilularia globulifera*, and *Ranunculus flammula* v. *reptans*. All species occurred as scattered individuals or small stands, and from a quantitative point of view all showed an insignificant degree of development.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 16). The water depths recorded on observation occasions during the vegetation period varied from 15 to 55 cm. In the winter the water depth was, as a rule, some decimeters greater.

The surface water quality was fairly stable. A lowering of the water level was, however, regularly accompanied by a weak increase in the specific conductivity. The lowest conductivity was recorded during winter high water level. Summary of surface water quality data (samplings in Aug. 1962, Sept., Nov. 1963, July, Aug., Sept. 1964; number of analyses in parentheses): Col 5—30, m=10 (4), Sp. cond. 64—74, m=70 μ S (6), pH 6.5—7.0, m=6.8 (6), Na 230—250, m=240 (5), K 29—30, m=30 (5), Mg 60—70, m=60 (5), Ca 120—160, m=140 (5), Fe 1—4, m=2 (4), Cl 190—230, m=210 (5), and P 0.2—0.3 μ mol/l (2), and Alk 58—82, m=66 μ eq/l (4).

The bottom (Fig. 42). Spheric and somewhat flattened lake ore concretions with a diameter of up to 4 cm were very common on the surface.

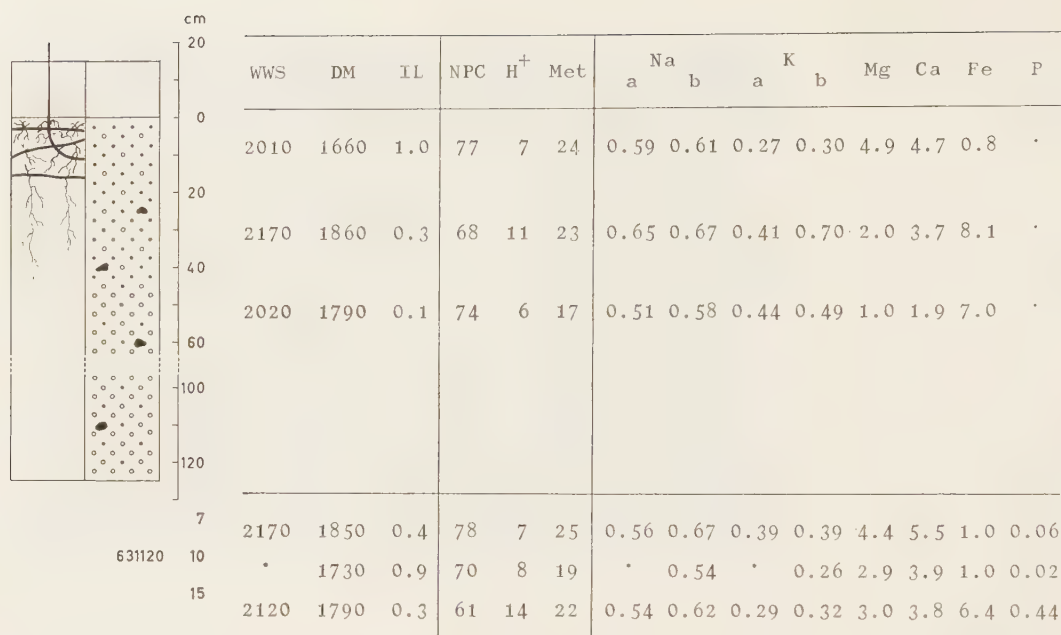


Fig. 42. Biotope 10 Rolsmosjön. Vertical section and soil analyses from 631120 and 640921.

Stratigraphy:

- 0—12 cm Gravelly sand. The superficial layer dark rust-coloured, but the underlying light ochre-coloured. This soil is fairly hard, due to the grains being coated by and the interspaces being filled with iron precipitated from upwelling subsoil water. Due to irregularities in the soil composition the water supply from below is uneven between different bottom areas. Therefore, the underside of the rust-coloured layer is not plane. There is, however, always a very distinct limit between the superficial layer with precipitated iron and the underlying soil without iron precipitation.
- 12—45 cm Grey stony, gravelly sand.
- 45—125 cm Grey stony and sandy gravel.

The coarse minerogenic substratum and the upwelling of subsoil water rich in iron characterized the bottom. The highest amount of extractable metallic cations, though very low throughout the

section, and the highest percentage of neutralization were obtained in the superficial layer with precipitated iron. The stony gravel showed, of course, the lowest amount of extractable metallic cations. The amount of extractable Na was about the same throughout the section. With the exception for one irregularity there was a downwardly increasing trend for K, while Mg and Ca clearly decreased in the mentioned direction. Very little Fe was extracted from the superficial ferruginous soil horizon, while the amount increased in the underlying layers without precipitated iron.

B. *Phragmites communis*

Rhizomes and roots (Fig. 42). The horizontal rhizomes were very superficially located, viz., in the main around 10 cm. Strongly undulated fine roots from thick ones were found down to 40 cm. Most of the fine roots occurred in the ferruginous layer. One to two

Fig. 43. Biotope 11 Rolsmosjön (in the background). — Photo S. Björk 640801.



basal nodes of some shoots had a few fine roots. (The basal nodes of shoots growing in deep water outside the biotope were very richly provided with bushy roots.)

Shoot density. Ca. 15.

Flowering time. About the second to third week in Sept. When regarded superficially at, the flowering time of *Phragmites* might have been expected to occur earlier in a biotope like this, which is openly exposed to the sun and seems to have an easily warmed up bottom. However, the supply of fairly cold subsoil water is probably the reason for the delayed development of the panicles.

Panicle frequency. In 1963 35 % and in 1964 5 %.

Further data in Tables 17—20, 22, 24.

Biotope 11

A. Environment

Situation (Fig. 38). Outside the eastern shore of the southeastern bay.

Physiographic survey (Fig. 43). The dense *Phragmites* reed-bed grows to the very shore which is bouldery. Above the

shore (N—S direction), i.e., east of the biotope, is a girdle of *Alnus glutinosa* bushes and trees, which is followed by stony pasture grazed by sheep. About 100 m east of the lake lies one of the five farms constituting the village of Rolsmo. For some years sewage from two dwelling-houses has been let out to the lake about 50—75 m to the north of the biotope. The local auxotrophifications were in 1966 registered by small and restricted increases in the *Phragmites* stand. From a third house sewage is infiltrated in the ground ca. 75 m from the shore line above the biotope.

The biotope is overshadowed in the morning. It is fairly sheltered against winds from all directions and hardly any wave action is noticeable during the vegetation period.

According to the local inhabitants the quantitative increase of *Phragmites* has proceeded very rapidly since the fifties.

Only two macrophyte species were intermingled in the *Phragmites* stand, viz., *Lemna minor* and *Fontinalis antipyretica*. The water surface was sometimes covered by *Lemna minor* and the water filled with *Fontinalis*.

The dry *Phragmites* stems often remain for one vegetation period.

The water (Table 16). The summer normal water depth was ca. 35 cm. The water depths noted on the observation occasions during the vegetation period varied from 20 to 50 cm.

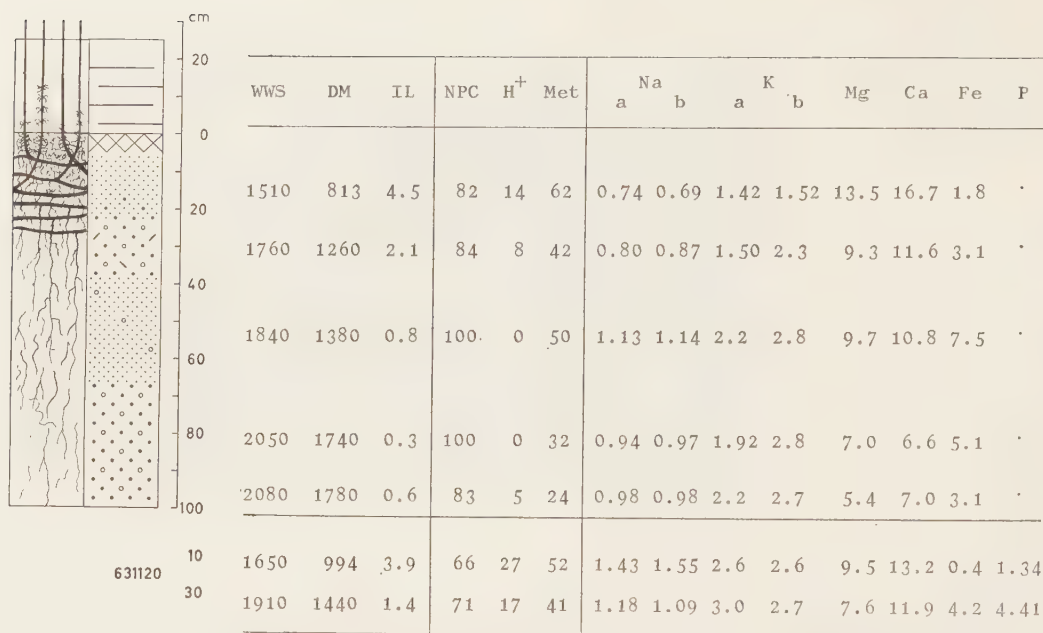


Fig. 44. Biotope 11 Rolsmosjön. Vertical section and soil analyses from 631120 and 640921.

Also in this biotope the lowering of the water level was accompanied by a rise in the specific conductivity, even during the vegetation period. While the Na concentration did not seem to be regularly affected by the fluctuations in the water level, the concentrations of Cl, Ca, and especially K increased when the water depth decreased. On the whole, the content in the surface water of K was fairly high in this biotope except during periods with exceedingly high water level.

Surface water was sampled on the same 6 occasions as in biotope 10. Water quality data (number of analyses in parentheses): Col 20—45, m=35 (4), Sp. cond. 72—98, m=79 μ S (6), pH 5.6—6.3, m=6.0 (6), Na 240—270, m=250 (5), K 48—140, m=88 (5), Mg 50—70, m=60 (5), Ca 140—200, m=150 (5), Fe 2—4, m=3 (4), and P 1.1—0.7 μ mol/l (2), and Alk 100—178, m=138 μ eq/l (4).

The bottom (Fig. 44). Above the more or less consolidated coarse detritus gyttja there was a 20 cm layer of very coarse *Phragmites* detritus (rapid accumulation of detritus).

Stratigraphy:

0—5 cm	Fairly consolidated coarse gyttja.
5—38 cm	In the upper part grey beige fine sand, in the lower part gravelly sand. Very rich in dead rhizomes and roots, for the most part probably of <i>Scirpus lacustris</i> . Also drift material.
38—ca. 68 cm	Grey fine sand.
ca. 68—ca. 98 cm	Grey sand, fairly rich in gravel.
98—100 cm	Brown beige gravelly sand.

The amounts of extractable metallic cations decreased downwards, but the percentage of neutralization was over 80 throughout the section. As for the

amount of K, which was fairly high at all levels, the lowest concentration was obtained in the upper part of the minerogenic soil. The concentrations of Mg and Ca decreased downwards.

B. *Phragmites communis*

Rhizomes and roots (Fig. 44). The horizontal rhizomes were fairly superficially located. The highest frequency occurred between 10 and 25 cm. Thick roots were common down to 50 cm and singles were found at 100 cm. Fine roots were common also at the 100 cm level. A fine root felt was developed at the bottom surface, but the development of roots from the basal shoot nodes was poor.

Shoot density. Ca. 60.

Flowering time. Second to third week in Sept.

Panicle frequency. Ca. 75 %.

Further data in Tables 17—20, 22, 24 (insertion levels given from detritus surface).

Lake Linnerydssjön

With Biotope 12

General Description

56°39'N, 15°9'E. Altitude 136 m a.s.l. Area 1.6 km².

The basin is a shallow depression in the moraine. The water level has been permanently lowered, 0.3 m in 1948. In the northern part of the basin emerged boulders are now scattered over the lake surface. In the southern part the depth is ca. 3 m. After the lowering the sediment limit reaches the water line, especially in the bays.

Until the summer of 1958 sewage and waste water from a dairy were let out directly into the northwestern part of the lake, which became heavily polluted. From the mentioned date the sewage and waste water have been collected in a lagoon from

which it is, via a rivulet, discharged into the southern part of Linnerydssjön.

THUNMARK (1937) gives the following water quality data from July 1935 (superficial water from the pelagial): Tr 220, Col 70, Sp. cond. 67 μ S, pH 6.8 and the lake colour dark brown.

From the central northern part of the lake the present author obtained the following water quality data in Sept. 1958 and in July 1959: Col 35/25, Sp. cond. 87/96 μ S, pH 6.7/6.6, and (O₂)s 82/86 ‰. At the same times the following figures were obtained from the central southern part of the lake: Tr 280/240, Col 35/20, Sp. cond. 85/95 μ S, pH 6.8/7.2, (O₂)s 89/100 ‰ and the lake colour on both occasions yellowish brown.

A comparison between the figures from 1935 and 1958—1959 reveals that the value for the water colour has decreased, but the specific conductivity shows a considerable increase. Without any doubt the turbidity of the water, caused by plankton and whirled-up sediments, has become greater in later years. In spite of this the transparency seems to have become higher than in 1935, which probably is due to the decrease of the water colour.

Due to the lowering of the water level and the pollution the limnologic conditions have been greatly changed in Linnerydssjön. From a quantitative point of view the hyperhydate and ephydate vegetation has shown a considerable increase in recent years. During the summer the water is turbid from plankton and in shallow water the bottom is overgrown with filamentous and other algae.

The northern bays are in a stage of being overgrown by luxuriant stands of *Equisetum fluvatile* (richly branched), *Phragmites communis*, *Scirpus lacustris*, and *Typha latifolia*. Lakewards from the reed-beds — in and along which *Lemna minor* is very frequent — large areas are covered by *Nuphar luteum* (the rhizomes often lifted up from the bottom and floating on the water surface) and *Nymphaea alba*. The islands are surrounded by broad belts of *Scirpus lacustris*. Also in southern Linnerydssjön there are large luxuriant stands of *Equisetum fluvatile*, *Scirpus lacustris*, and *Typha latifolia* as well as of *Nuphar luteum*. Other macrophyte species with high frequency are: *Alisma*



Fig. 45. Biotope 12 Linnerydssjön. — Photo S. Björk 660910.

plantago-aquatica, *Carex rostrata*, *Eleocharis palustris*, *Glyceria fluitans*, *Lysimachia thyrsiflora*, *Solanum dulcamara*, and *Sparganium erectum*.

In 1966 parts of the macrophyte stands in the northwestern bay were treated with herbicides and a filling-in with excavated material was started. Due to the pressure of the filling on the gyttja there was a rise of the organogenic sediments in the surrounding lake areas.

However, that vegetation, which undoubtedly was most characteristic for the lake before it was lowered and polluted, is still represented here and there in minerogenic shore reaches, where *Isoëtes lacustris*, *Littorella uniflora*, *Lobelia dortmanna*, *Pilularia globulifera*, and *Ranunculus flammula* v. *reptans* are frequent. Furthermore *Sparganium Friesii* and *Myriophyllum alterniflorum* are common in different parts of the lake.

Biotope 12

A. Environment

Situation (Fig. 38). Centrally in the large homogeneous *Phragmites* stand covering the northwestern bay.

Physiographic survey (Fig. 45). Along the shore line there was a curtain of *Salix*, *Betula*, and *Alnus* bushes and above this there was grass-covered ground with

scattered oaks and birches, separating the lake from the village of Linneryd. The biotope, shaded in the late afternoon, was sheltered against winds and no wave action was noticeable.

The only macrophyte species besides *Phragmites communis* in the biotope was *Lemna minor*, which was of small size but frequent.

The dry *Phragmites* stems often remained erect for at least one vegetation period.

The water (Table 16). On the sampling occasions the water depth varied from 0 to 35 cm. In surface water samples the specific conductivity varied from 120 to 180 μS and pH from 6.0 to 6.4. The interstitial water (sampled in dug pits) of the surface soil was characterized by having decidedly lower pH and somewhat higher specific conductivity than the surface water. The lowest concentrations for K were found during the period of most rapid growth of *Phragmites*.

In interstitial water obtained by suction from fresh soil samples (Nov. 1963) only the Cl content was determined. At 10 cm the Cl content was 1.090, at 50 cm 845, and at 90 cm 775 $\mu\text{mol/l}$.

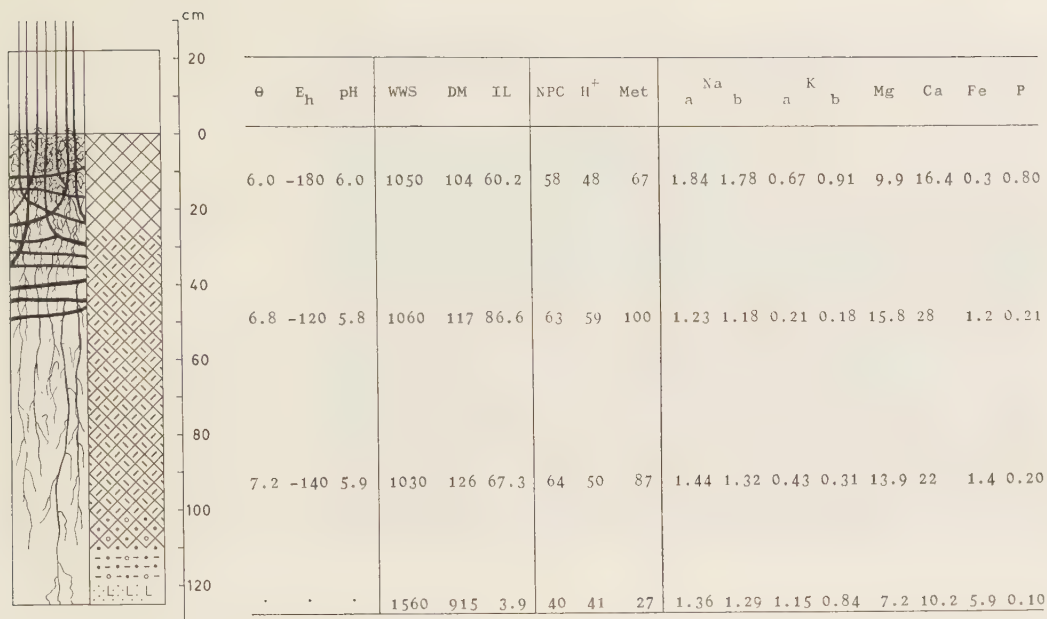


Fig. 46. Biotope 12 Linnerydssjön 631120. Vertical section and soil analyses.

The bottom (Fig. 46). The surface of the consolidated gyttja was covered by a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

- 0—ca. 25 cm Fairly loose dark brown coarse gyttja. Even transition into the underlying soil.
- ca. 25—103 cm Dark brown drift gyttja, slightly sandy and rich in wood.
- 103—110 cm Transition layer of sandy and somewhat gravelly gyttja, in the upper part brown, downwards greyish.
- 110—120 cm Grey gravelly sand with some organic matter.
- 120—125 cm Grey silty sand.

The soil at the two sampled levels of the coarse, but fairly homogeneous, drift gyttja constituting the main part of the section showed about the same amounts of extractable metallic cations and percentage of neutralization. How-

ever, the content of extractable K was about twice as high at the lower as at the upper level. Both the surface and the bottom layers in the section had lower amounts of extractable metallic cations due to their lower contents of Mg and Ca and also lower percentage of neutralization than the intermediate drift gyttja. The two mentioned levels showed, however, decidedly higher contents of extractable K. The amounts of extractable Fe increased downwards, while the amount of P decreased.

With respect to the distribution of the analysed elements it is plausible that the relatively higher amounts of Na, K, and P in the surface layer than in the underlying organogenic soils with higher degree of consolidation may be due to the pollution of Linnerydssjön in recent times. However, as the sampling was carried out in late November it is also possible that in this layer, which was very rich in fine roots from vertical



Fig. 47. Biotope 13 Veden (in the foreground). The marginal zone of the reed-bed and also the cape with the bushes are floating. — Photo S. Björk 660910.

rhizomes, the mentioned elements could have been released from dead fine roots.

B. Phragmites communis

Rhizomes and roots (Fig. 46). The highest frequency of horizontal rhizomes was found between 15 and 40 cm. Thick roots occurred down to the minerogenic soil. Fine roots were found, though very sparsely, also in the minerogenic soil at 125 cm. A dense, fine root felt was developed between 0 and 15 cm. No or very few of the basal shoot nodes had fine roots.

Shoot density. In 1962 ca. 140, in 1964 ca. 120.

Flowering time. Dependent on the weather and water level conditions the panicles can come in full flower from the last week in Aug. to the second week in Sept.

Panicle frequency. Fairly great variations between different years were noticed. In 1962 ca. 70, in 1964 ca. 40 ‰.

Further data in Tables 17—22, 24.

Lake Veden

With Biotope 13

General Description

56°42'N, 15°20'E. Altitude 144 m a.s.l. Area 0.4 km². Max. depth 3 m.

The lake is an enlargement of the river Ronnebyån. In connection with the rebuilding of the water power station at Skogsholm (Öljeholm) about 1940 the water level of Veden was raised 0.3 m. The superficial bottom deposits consists of wood fibre sediments. At high water level the submerged land areas are covered with a thin fibre layer.

The lake is heavily polluted by waste water from the sulphite paper-mill and the sewage treatment plant in Lessebo, see Fig. 39. Besides the figures given there (sampling station 12), the following data of water quality from the pelagic superficial layer are given (samplings in Sept. 1958 and July 1959): Tr 210/210, Col 30/20, KMnO₄-cons. 200/160 mg/l, Sp. cond. 83/79 µS, pH 5.6/5.7, Cl 340/370 µmol/l, and (O₂)s 22/26 ‰.

There are large, dense reed-beds of *Phragmites communis* in especially the northern and southern parts of the lake as well as around the islands and also stands of *Scirpus lacustris* and *Typha latifolia* occur. Plaur formations with two types of genesis (cf.

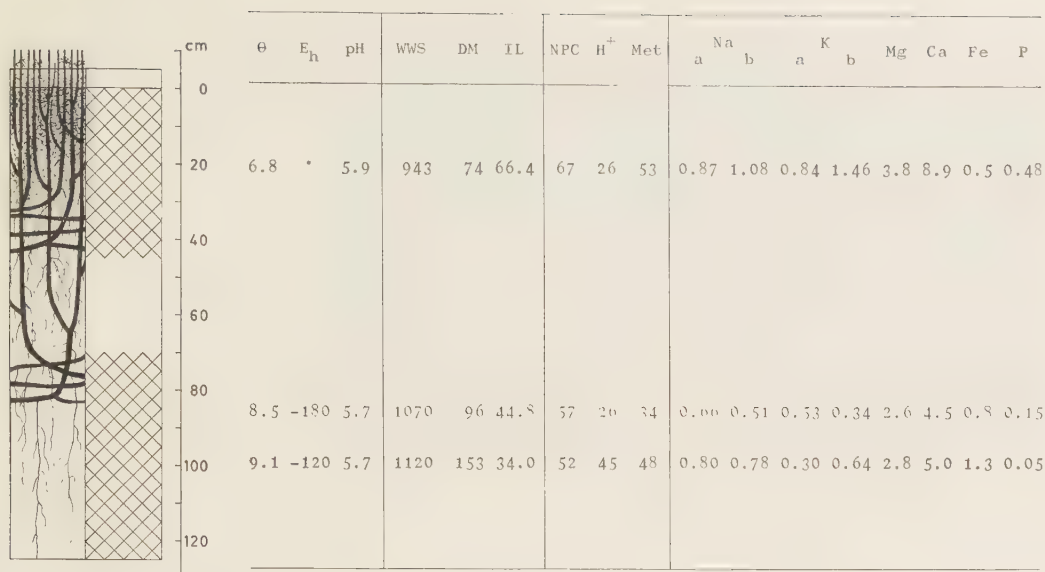


Fig. 48. Biotope 13 Veden 631119. Vertical section and soil analyses.

below, biotope 13) are common in the northern part. In the large areas with luxuriant water lilies, above all *Nymphaea alba*, but also *Nuphar luteum*, the frequency of *Utricularia vulgaris* is very high and *Lemna minor* is common. The waterfowl fauna is rich (*Cygnus olor* breeds in the lake).

Biotope 13

A. Environment

Situation (Fig. 38). On the eastern side of one of the small islands in the northern part of the lake.

Physiographic survey (Fig. 47). The island, bordered by *Myrica gale*, *Salix* and *Rhamnus frangula* bushes, is covered by *Betula* and *Picea*. Due to this the biotope was shaded during the late afternoon. It was fairly sheltered against winds and no wave action was noticeable there.

The *Phragmites* stand was pure. As a rule the dry stems remain for one vegetation period.

The water (Table 16). The quality of the surface water is variable and dependent on the amount and the dilution of sewage and industrial waste

water discharged into the stream Lesseboån. According to the available water analyses the specific conductivity varied between 79 and 130 μS during the vegetation periods 1963–1964 and pH from 5.4 to 6.0. A subsample of the water having a specific conductivity of 130 μS was kept in a plastic bottle in darkness and at a temperature of ca. 20°C for 6 months. Then the conductivity had risen to 200 μS . Especially the concentrations of K, Mg, and Ca increased with increasing pollution.

The bottom (Fig. 48). The rise in the water level and the supply of waste water have caused a complicated and interesting growth of the *Phragmites* rhizome and root system, which also is responsible for the peculiar soil stratigraphy.

Stratigraphy:

0—ca. 45 cm Layer of coarse gyttja deposited in the multi-branched upper part of the *Phragmites* rhizome and root system.

ca. 45—70 cm	Water.
70—95 cm	Grey-brown, very loose, coarse gyttja, rich in <i>Phragmites</i> detritus as well as in wood fibre.
95—125 cm	Dark brown gyttja, extremely rich in dead, black, tough, rather fine roots. Boulders at 125 cm.

The substratum below 95 cm represents the bottom sediment deposited before the pollution of Ronnebyån began as well as before the rise in the water level in Veden took place. Above this, in the grey-brown gyttja containing wood fibres, *Phragmites* rhizomes were very common. The new environmental conditions caused by the pollution were obviously favourable for *Phragmites*. From the shoots growing in ca. 70 cm deep water, a great many roots were developed below the water surface. In this root felt detritus was collected and a second bottom layer was successively developed. In the biotope this layer contained horizontal rhizomes and the vertical rhizomes were very richly branched. The layer had such a buoyance that it was possible to walk on it. In other parts of the reed-bed there were freely floating formations (cf. Fig. 47).

The percentage of neutralization was low throughout the section. The highest value was obtained in the superficial coarse detritus layer which also had the highest amount of extractable cations. All the analysed elements except Fe were also quantitatively best represented in this layer.

B. *Phragmites communis*

Rhizomes and roots (Fig. 48). The horizontal rhizomes occurred in two

well distinguishable layers. In the lower one there were besides the living, also a great many dead horizontal rhizomes. The upper layer was developed in the lower part of the superficial coarse gyttja layer. Part of the vertical rhizomes reached down to 70—80 cm, but others emanated from the upper layer of horizontal rhizomes. Single thick roots were found down to 125 cm. In the intermediate water layer the frequency of thick roots, richly provided with fine roots, was high. The superficial coarse gyttja was densely interwoven with fine roots, constituting a tough felt. Thick as well as fine roots were long and slender. One to four of the basal shoot nodes had fine roots.

The observations indicate that a floating *Phragmites* stand will gradually be developed here, although not according to the common scheme for plaure formation. Plaurs developed in both ways occurred in Lake Veden.

Shoot density. Ca. 130.

Flowering time. The flowering occurred in the middle of Sept.

Panicle frequency. Ca. 65 %.

Further data in Tables 17—20, 22, 24.

Lake Hammaren

With Biotope 14

General Description

56°40'N, 15°12'E. Altitude 134 m a.s.l. Area 0.2 km².

The lake is a shallow enlargement of the river Ronnebyån. During the observation period 1958—1966 there has been a marked increase in the quantitative development of the macrophyte vegetation. Hammaren is nowadays overgrown to such an extent that

Fig. 49. Biotope 14 Hammaren. — Photo S. Björk 620820.



during the summer the river course is practically the only open water.

Until 1928 Ronnebyån including the lakes passed by it were used for floating timber. The water level of Lake Viren, situated downstream from Hammaren, is now regulated, and so is, as mentioned, Lake Veden upstream from Hammaren. The water level in Hammaren follows that in Viren.

In addition to the water quality data in Fig. 39 (station 13), the following analyses (samplings in Sept. 1958 and July 1959) of water from the superficial layer in the connecting channel between Hammaren and Viren are given: Col 35/30, KMnO_4 -cons. 200/150 mg/l, Sp. cond. 85/78 μS , Cl 350/330 $\mu\text{mol/l}$, and $(\text{O}_2)s$ 24/46 ‰.

In the hyperhydate vegetation *Phragmites communis* is the dominating species, covering large areas. Obviously *Phragmites* clones with different genetic constitution are represented, as there are sharp boundaries between stands with markedly different characteristics with respect to shoot size, panicle type, leaf colour, flowering time etc. Large and dense reed-beds of *Typha latifolia* as well as stands of *Carex rostrata* also occur. On both sides of the river course the water surface is often covered by *Potamogeton natans* and *Nymphaea alba*, and in and around the hyperhydate stands *Lemna minor* is very frequent. *Utricularia vulgaris* is very common and well developed.

Biotope 14

A. Environment

Situation (Fig. 38). Centrally in the northern part of Hammaren, east of the channel of Ronnebyån.

Physiographic survey (Fig. 49). The biotope is exposed to winds from all directions. No wave action was noticeable, but there was during the vegetation period a continuous weak flow of water through the reed-bed.

With the exception of *Lemna minor* no other macrophyte species besides *Phragmites communis* was found. The frequency of *Lemna minor* was sometimes high, and large areas were covered by this species.

In some years the dry *Phragmites* stems were broken in the spring, in others they remained for the next vegetation period.

According to information from the local inhabitants, the overgrowth of Hammaren with *Phragmites* has taken place during the last decades. The overgrowth was primarily started by *Equisetum fluviale* which for some time from a quantitative point of view was the dominating hyperhydate species. Also *Scirpus lacustris* was said to have been common. The information about the succession with respect to *Equisetum* and *Phragmites* was plainly proved in the biotope by the rich occurrence of dead *Equisetum* rhizomes and roots.

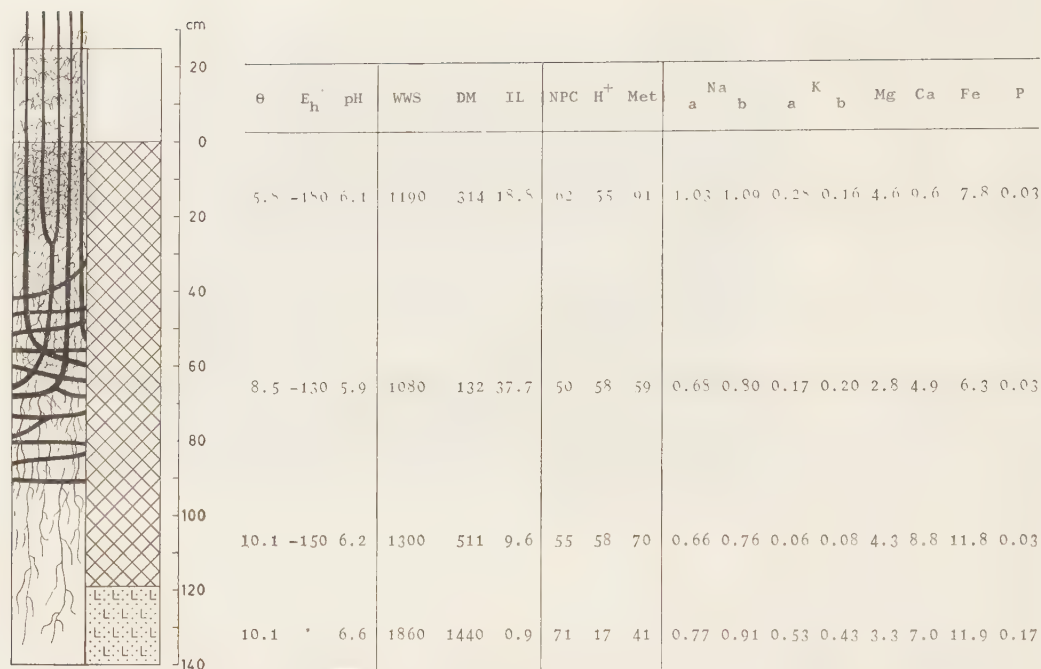


Fig. 50. Biotope 14 Hammaren 631121. Vertical section and soil analyses.

The water (Table 16). As in Lake Veden the water quality was variable and dependent on the water flow in Ronnebyån and on the amount of sewage and industrial waste water discharged into the stream Lesseboån. During the vegetation period specific conductivity values from 69 to 130 μ S were obtained. The corresponding variation in pH was 5.5—5.9 and for Cl 245—590 μ mol/l.

The bottom (Fig. 50).

Stratigraphy:

- 0—45 cm Coarse gyttja with grey brown and brown layers. Dead rhizomes and roots of *Equisetum*.
- 45—119 cm Dark brown coarse gyttja, in part very loose. Dead *Equisetum* rhizomes and roots occurred throughout this layer.
- 119—140 cm Grey beige silty fine sand. Also here, though sparser, rhizomes and roots of *Equisetum*.

The percentage of neutralization was fairly low in the gyttja. The highest amount of extractable metallic cations was obtained in the superficial layer, which also showed the highest figures for Na, Mg and Ca. Noticeably low content of K was found in the lower part of the gyttja. The amount of extractable Fe increased downwards, while P was low in all analysed gyttja layers. Though the amount of extractable metallic cations, on a volumetric basis, was smaller in the minerogenic soil than in the gyttja, the concentration of K was definitely higher. In the gyttja there was a clear gradient for K, implying downwards decreasing amounts.

B. *Phragmites communis*

Rhizomes and roots (Fig. 50). Horizontal rhizomes occurred down to at least 90 cm. The highest frequency was

found at 50—60 cm. Thick roots reached down to the minerogenic soil and at the 130 cm level some fine roots were found. The greatest concentration of fine roots occurred down to 25 cm. Some of the shoots were provided with bushy fine roots at the nodes up to 30 cm from the bottom. During periods of heavy pollution these roots were overgrown with fungus slime.

Shoot density. In 1961 ca. 75 (fairly many small shoots developed), in 1962 ca. 55.

Flowering time. First to second week in Sept.

Panicle frequency. In 1961 ca. 50 %, in 1962 ca. 70 %. The variations probably due to changes in the water depth.

Further data in Tables 17—22, 24.

Lake Tiken

With Biotope 15

General Description

56°31'N, 14°59'E. Altitude 125 m a.s.l. Area 6.5 km². Max. depth 8 m.

The basin, formed by glacial excavation, is divided into several more or less separated parts. The northern part constitutes the largest open water area. The shores are here minerogenic. As a result of the lowering of the lake, shallow areas with bottoms of fine-grained minerogenic soils have been accessible to macrophyte vegetation. The water level is regulated by a dam at the outlet.

The stream Bräkneån runs through the lake, which serves as recipient for sewage and industrial waste water from the market town of Tingsryd.

THUNMARK (1937) gives the following water quality data from Aug. 1935 (superficial water from the pelagial): Tr 280, Col 59, Sp. cond. 83 μ S, pH 6.9, and lake colour yellowish brown.

From northern Tiken (samplings in May

and Oct. 1960) I obtained the data: Tr 260/310, Col 25/20, Sp. cond. 110/110 μ S, pH 7.1/6.9, Cl 380/390 μ mol/l, (O₂)s 104/93 ‰, and lake colour yellowish green-brown/yellowish green. On the corresponding occasions the data from southernmost Tiken were: Tr 290/340, Col 20/15, Sp. cond. 98/110 μ S, pH 7.2/6.9, Cl 330/350 μ mol/l, (O₂)s 106/96 ‰, and the lake colour the same as in northern Tiken.

A comparison between the conditions in 1935 and 1960 reveals that the conductivity has increased while the colour has decreased. In spite of the lighter colour the transparency is about the same as in 1935, which, without doubt, is a result of the successively increasing turbidity of plankton.

From a quantitative point of view *Phragmites communis* is the most prominent macrophyte species in northern Tiken. It occurs in large expanding stands of great homogeneity. *Scirpus lacustris*, *Carex elata*, *C. rostrata*, and *C. vesicaria* are also common as well as, in some shore reaches, *Iris pseudacorus* and *Glyceria fluitans*. The southern part of Tiken is poorer in macrophyte vegetation than the northern one.

Biotope 15

A. Environment

Situation (Fig. 38). Centrally in one of the largest homogeneous *Phragmites* stands southeast of the market town Tingsryd.

Physiographic survey (Fig. 51). The ground above the shore (NNW—SSE direction) is covered by spruce (*Picea abies*) and mixed broad-leaved (*Betula*, *Populus*, *Alnus*) and coniferous (*Pinus*, *Picea*) forest. Along the shore there is a zone with *Myrica gale* and *Molinia coerulea*.

The biotope is overshadowed in the early morning. It is exposed to southwestern winds but in the vegetation period the wave action is rather weak.

The *Phragmites* stand was pure. The dry stems were regularly broken in the spring.

The water (Table 16). On the observation occasions during the vegetation period the water level varied from 0 to

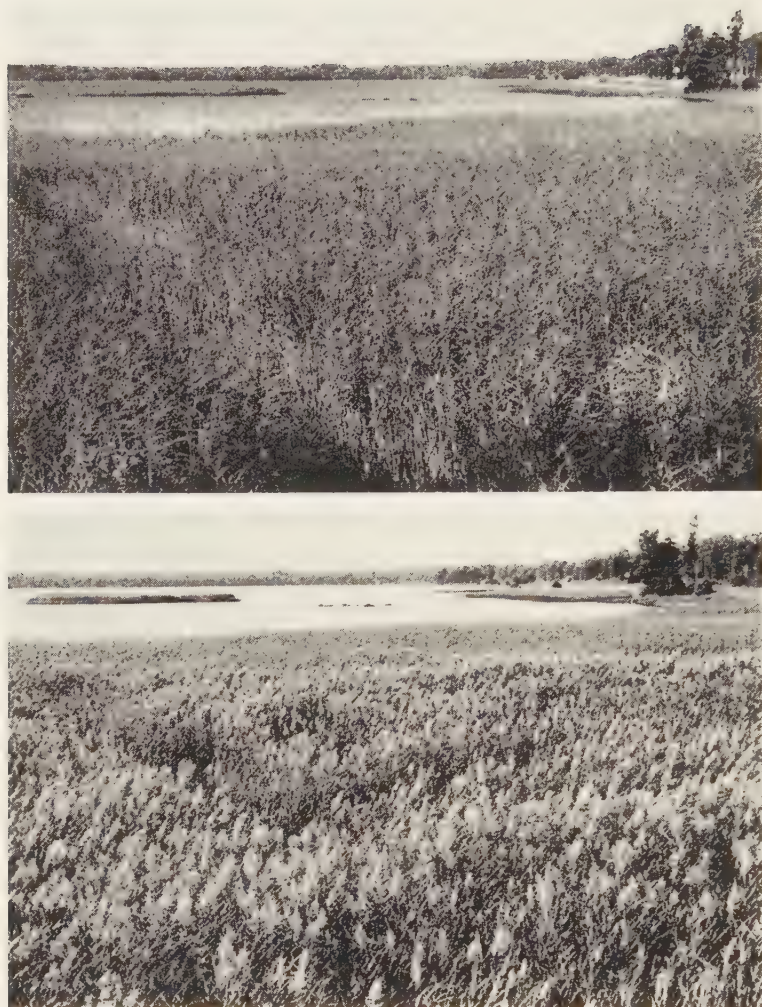


Fig. 51. Biotope 15 Tiken. Top: Photograph from 630921. Panicle frequency $< 10\%$. Flowering late, panicles small. Bottom: Photograph from 640815. Panicle frequency ca. 50% . Flowering early, panicles large. — Photo S. Björk.

ca. 50 cm. A lowering of the water level was accompanied by a rise in the specific conductivity, which seemed to be caused by the supply of subsoil water.

The conductivity of the interstitial water, sampled in dug pits, also increased with the lowering of the water level. The rise in the conductivity was due to increases in alkalinity and in the concentrations of Na, Mg, Ca, and Cl. The concentration of K showed a minimum before the end of the vegetation period, which probably was caused by

the potassium uptake of the plants. The amount of Fe varied with the level (and the oxidizing conditions characteristic thereof) from which the sampled water originated (cf. below).

The bottom (Figs. 52 and 53). The surface was covered by a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

0—15 cm Brown organogenic layer, the upper half consisting of coarse detritus, the lower half mainly consisting of *Phragmites* roots.

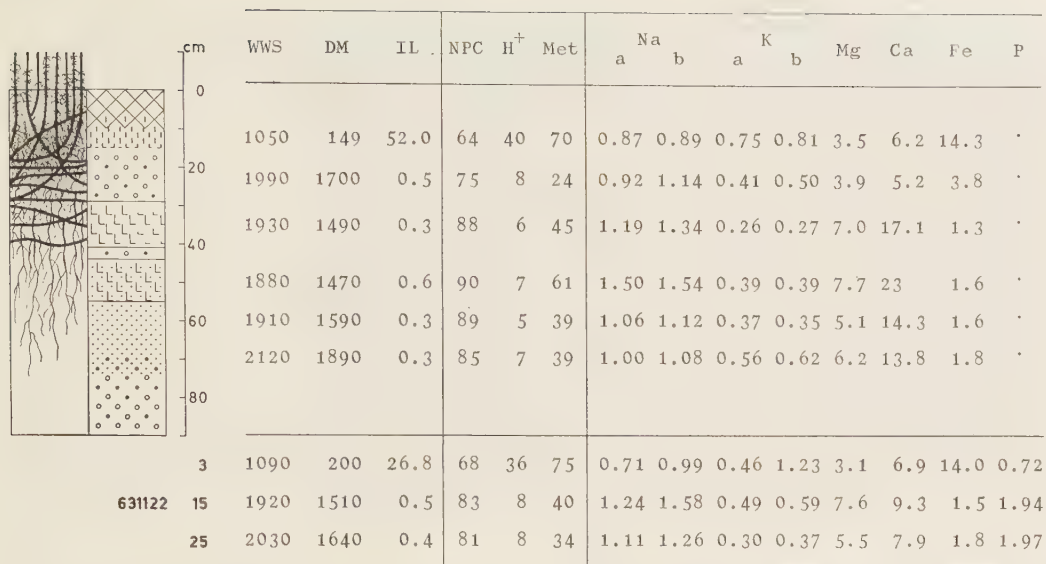


Fig. 52. Biotope 15 Tiken. Vertical section and soil analyses from 631122 and 640815.

The surface coloured by precipitated iron.

15—29 cm Grey sandy gravel (here and there gravelly sand).

29—41 cm Very hard, dense and mostly pure silt (only here and there with some fine sand).

41—44 cm Grey gravelly sand.

44—55 cm Very hard sandy silt.

55—90 cm In the upper part grey fine sand, downwards gradually more sandy and gravelly.

The organogenic layer, developed through the growth of *Phragmites*, showed the highest amount of extractable metallic cations but also the highest figure for hydrogen ions, thus giving this layer the lowest percentage of neutralization. The highest value for extractable Fe was obtained here.

Among the different minerogenic soils the silty soils had higher amounts of extractable metallic cations (especially Ca) than the sandy and gravelly ones. The supply of subsoil water, rich in electrolytes, from the supralittoral takes place in the coarse-grained layers.

B. *Phragmites communis*

Rhizomes and roots (Figs. 52 and 53). The highest frequency of horizontal rhizomes occurred between 20 and 35 cm. The lowest noted level was 40 cm. Thick roots were common at the 50 cm level and had a recorded lowest depth occurrence of 70 cm, which, on the whole, was the greatest depth at which roots were found at all.

An extraordinarily dense and pure felt of fine roots was developed in the



Fig. 53. Biotope 15 Tiken. Core from the upper 30 cm soil layer. Left: Unwashed. Right: Washed for showing the density of the *Phragmites* root felt.

lower half of the organogenic soil layer and the upper 10 cm of the underlying sandy gravel. The lower 1—5 nodes of the shoots often had fine roots.

Shoot density. Ca. 100 (80—120).

Flowering time. During years with relatively high panicle frequency, which is due to, among other things, the water level conditions, the panicles came into full flower during the second to third week in Aug.

Panicle frequency (Fig. 51). The frequency was highly variable between different years. In 1963 it was definitely below 10 %, in 1964 40—50 %, and in 1965 not a single panicle was developed in the whole large stand within which the biotope was situated. From these three years, 1964 was the one characterized by the lowest prevailing water level conditions during the vegetation period.

Further data in Tables 17—20, 22—24.

Lake Ängsjön

With Biotopes 16—17

General Description

56°24'N, 15°19'E. Altitude 101 m a.s.l. Area 0.4 km². Max. depth 22 m.

The surroundings of Ängsjön are covered by forests with the exception for some cultivated ground to the west and north of the lake. The shores (here and there very steep) are minerogenic, with a well-developed zone with *Myrica gale*. Lake iron ore occurs. On the whole the lake is very little affected by human activity.

The water is oligohumic and highly transparent. Water quality data (analyses of pelagic water from the superficial layer; samplings in Oct. 1958 and Aug. 1959): Tr 650/610, Col 2/4, Sp. cond. 57/59 µS, pH 6.8/7.2, and (O₂)_s 99/106 %.

The hyperhydate and ephydate vegetation

is sparse, consisting of small stands of *Carex rostrata* (most common), *Eleocharis palustris*, *Equisetum fluviale*, *Phragmites communis*, and *Scirpus lacustris* as well as of *Nuphar luteum* and *Potamogeton natans*. The greatest noted depth for *Nuphar luteum* was 2.7 m. However, there is a rich elodeid and isoetid vegetation with meadows of *Juncus bulbosus* and *Myriophyllum alterniflorum* and dense carpets of *Isoetes lacustris*, *Littorella uniflora*, *Lobelia dortmanna*, and *Subularia aquatica*. With respect to the characteristic features of the macrophyte vegetation Ängsjön is classified as a *Lobelia*-lake (SAMUELSSON 1925, pp. 7—8).

The presence in Ängsjön of the planktic diatom species *Tabellaria Teilingii* is reported by BJÖRK (1960).

Biotopes 16—17

A. Environment

Situation (Fig. 38). Investigations were carried out in two different *Phragmites* clones growing at the south shore in the proximal part of the western bay of the lake. The distance between the biotopes was 40 m. The western clone was characterized by short and the eastern by tall shoots. Biotope 16 was situated centrally in the western and biotope 17 centrally in the eastern clone.

Physiographic survey (Figs. 54 and 57). Above the shore line (E—W direction) there is mixed broad-leaved coniferous forest and along the shore a zone with *Myrica gale*, *Molinia coerulea* and *Carex rostrata* outside a marginal, fairly dense tree girdle of *Betula* and *Alnus*. In spring and autumn the biotopes are overshadowed in the morning and in the afternoon. Both biotopes are exposed to northerly winds, but the wave action is weak.

Both clones grow on the top and on the outer slope of a sandy and gravelly bank. Contrary to the conditions in the western clone (with biotope 16), the eastern one is best developed in deep water. The bank is here overlaid with gyttja.

In biotope 16 (shallow water, minerogenic bottom) as well as in the corresponding area of the eastern clone, the following plant species were noted besides *Phragmites com-*



Fig. 54. Biotope 16 Ängsjön. In the background the stand with biotope 17. — Photo S. Björk 620909.

munis: *Carex rostrata*, *Eleocharis palustris*, *Equisetum fluviatile*, *Juncus bulbosus*, *Littorella uniflora*, *Lobelia dortmanna*, *Subularia aquatica*. All species were represented by only scattered individuals and small stands.

On the lakeward slope of the bank overgrown by the eastern clone, the intermingling with isoetids increased and in biotope 17 (water depth ca. 2 m) there was a dense carpet of *Isoëtes lacustris* with an average leaf length of 15 cm. (In the outer margin of the *Phragmites* stand, where the water depth was 270 cm, *Isoëtes* individuals with 20 cm long leaves occurred.)

The eastern stand (with biotope 17) is not very old in the lake according to information from the local inhabitants, whose attention was attracted to this stand by its noticeably tall shoots which deviate from the common *Phragmites* types in the lakes of this oligotrophic region.

Unfortunately it was not possible to choose a biotope 17 on the bank where the environmental conditions were closely correspon-

dent to those in biotope 16. This was due to the fact that in the shallow water area the leaves of the tall shoots of the eastern clone were often eaten by animals, probably elk.

The dry *Phragmites* stems were regularly broken by the ice in the spring.

Biotope 16

The water (Table 16). The recorded water depths varied from 0 to 35 cm during the vegetation period. The quality of the surface water in the submerged biotope closely corresponded to that found in biotope 17. In samples from 1962 and 1963 the specific conductivity was 56—57 μS and pH 6.7—6.8. The content of tot. P in a sample from Sept. 1963 was 0.1 $\mu\text{mol/l}$.

Interstitial water was sampled in a 40 cm deep pit in the emerged bottom

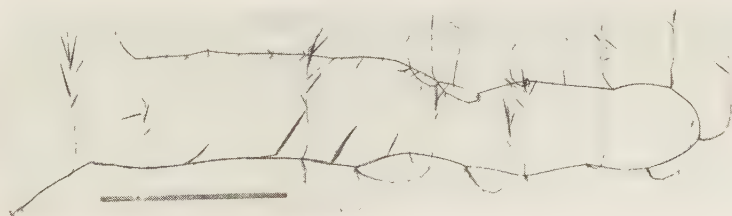


Fig. 55. *Phragmites* runner from biotope 16 Ängsjön 620909. Measuring stick = 1 m.

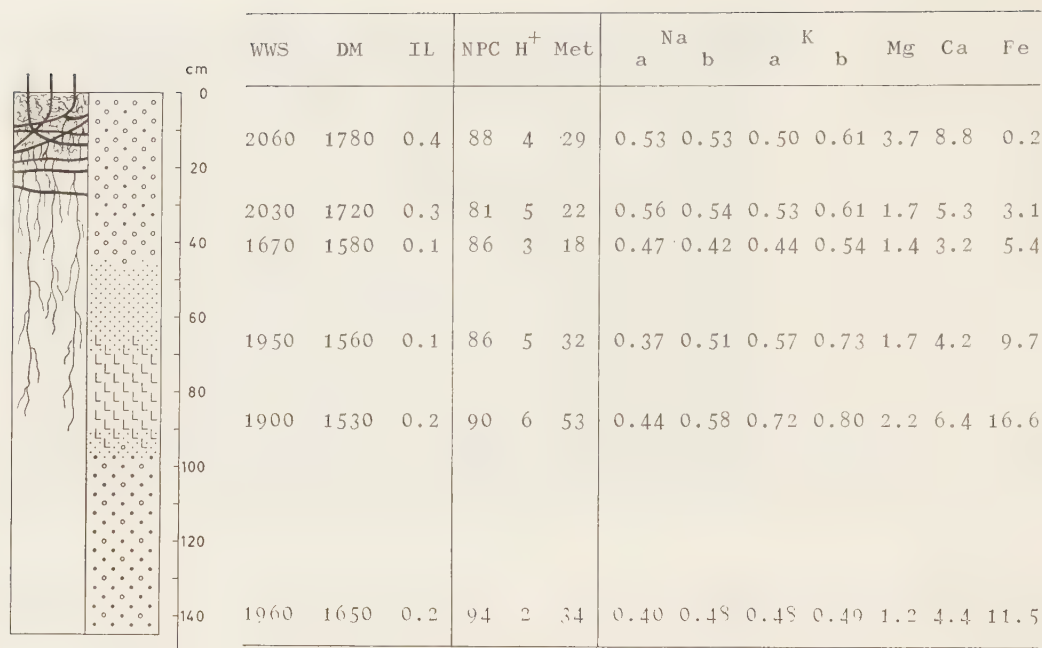


Fig. 56. Biotope 16 Ängsjön 640829. Vertical section and soil analyses.

in Aug. 1964. The pit was immediately filled with water from the highly porous sand and gravel. The interstitial water differed from the surface water especially in having higher alkalinity and higher concentrations of K, Mg, Ca, and Fe.

The bottom (Fig. 56). The surface is coarse minerogenic soil without any detritus covering.

Stratigraphy:

- 0—5 cm Rust-coloured sandy gravel.
- 5—37 cm In the upper part grey-beige sandy gravel, downwards more pure grey sand.
- 37—42 cm Gravel.
- 42—145 cm In the upper part grey fine sand, downwardly with gliding transition to silt with fine sand. At about 90—95 cm gliding transition to grey gravelly sand.

The lowest amount of extractable metallic cations (18 meq/l) was obtained

in the most coarse-grained layer, viz., the gravel at about 40 cm. On the other hand, the highest figure for extractable metallic cations was found in the silty soil at about 85 cm. The soil at the level immediately below the layer rust-coloured from precipitated iron, showed the highest loss on ignition and the highest content of Mg and Ca as well as the lowest amount of extractable Fe in the whole section. The content of Fe increased downwards, but for the rest the analysed elements were fairly evenly distributed throughout the section. The variations were dependent on the variations in the fractions of the minerogenic soil.

B. *Phragmites communis*

Rhizomes and roots (Fig. 56). The horizontal rhizomes were growing noticeably superficially. They had their



Fig. 57. Biotope 17 Ängsjön 620909. — Photo S. Björk.

highest frequency between 10 and 20 cm. One of the characteristic properties of this clone is that horizontal rhizomes (in some cases originally bent-down shoots) are often found growing upon the bottom as long runners provided with shoots and with roots loosely anchored in the bottom (Fig. 55).

The lowest level at which fine roots, emanating from thick ones, were found was 90 cm. Fine roots, especially emanating from vertical rhizomes, were common in the rust-coloured sandy gravel and downwards to 15 cm.

Shoot density. Ca. 18 (1963).

Flowering time. The flowering occurred fairly late, viz. during the period from the third week in Sept. to the first week in Oct. (biotope over-shadowed).

Panicle frequency. 65 % (1963).

Further data in Tables 17—20, 22, 24.

Biotope 17

The water (Table 16). The depths recorded during the vegetation period varied from 195 to 235 cm. The specific conductivity of the surface water was

55—57 μ S and pH 6.7—6.8. The alkalinity was low.

The bottom (Fig. 58). The bottom was covered by a dense carpet of long-leaved *Isoetes lacustris*.

Stratigraphy:

0—6 cm	Dark brown (rust-coloured) gravelly sand with pebbles and intermingled with gyttja.
6—12 cm	Light ochre-coloured loose gyttja.
12—18 cm	Darker, somewhat rust-coloured gyttja.
18—25 cm	Dark olive-green brown gyttja.
25—33 cm	Grey brown, heavily gravelly gyttja.
33—39 cm	Dark greenish brown, dense and elastic gyttja.
39—61 cm	Gravelly and stony sand, down to 45 cm intermingled with gyttja.

The complicated stratigraphy indicates a long series of changes in the environmental conditions. The percentage of neutralization is lower throughout in this section than in the one obtained in biotope 16. The amount of extractable Na is about the same as in biotope 16, but as for K the amounts are lower. Due to the low amounts of Mg, Ca and Fe the sum of the analytically determined metallic cations is

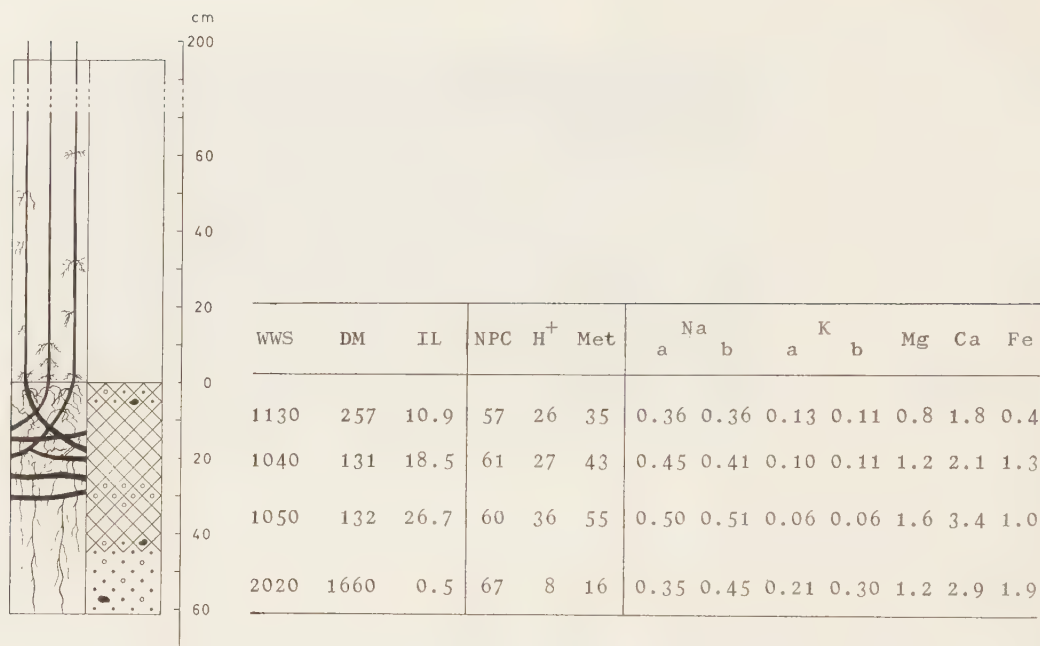


Fig. 58. Biotope 17 Ängsjön 640829. Vertical section and soil analyses.

extraordinarily low when compared with the total amounts of extractable cations (as estimated from the pH displacement in the HAc extracts) in the gyttja soils. On equivalent basis the sum of the analytically determined elements does not constitute more than ca. 20 % of the total amount of extractable metallic cations. In the underlying minerogenic soil the conditions with respect to extractable metallic cations were similar to those found in biotope 16.

B. *Phragmites communis*

Rhizomes and roots (Fig. 58). The highest frequency of horizontal rhizomes was found between 15 and 25 cm, but rhizomes occurred down to at least 40 cm. Thick fine roots occurred down

to ca. 60 cm, but at the lower levels the frequency was very low. In the minerogenic soil the fine roots were characteristically undulated, but in the gyttja they were straight and very thin. No concentration of fine roots was noted in the upper soil layer. As is common for *Phragmites* growing in deep water, multibranched bushy roots were developed on the lower nodes of the shoots, in this case up to 60 cm from the bottom.

Shoot density. Ca. 25.

Flowering time. First to second week in Sept.

Panicle frequency. In 1963 ca. 25 %.

Further data in Tables 17—20, 22, 24.

Survey of the Analyses

From a regio-limnologic point of view this region resembles the Aneboda region. The reason for including the biotopes 10—17 is that the series of ecologically interesting constellations of environmental conditions and *Phragmites* types which have been found here not have as good counterparts in the Aneboda region.

In the fairly intact Lake Ängsjön two different clones growing at the same shore reach were studied. The other five lakes are auxotrophicated through lowering (Rolsmosjön), by lowering and sewage pollution (Linnerydssjön and Tiken), and by pollution of waste water, above all from a sulphite paper-mill (Veden and Hammaren). Also in Rolsmosjön two different clones were investigated.

Human activity has brought about considerable changes in the limnic macrophyte vegetation, comparable to those in the Aneboda region.

In spite of the lowering of the lake, the environmental conditions in biotope 10 Rolsmosjön greatly resembled those prevailing in more or less intact biotopes within the region. In this survey biotope 10 is therefore, together with 16—17 Ängsjön treated as "intact" and compared with the auxotrophicated biotopes 11—15.

A. Environment

Most of the following macrophyte species, typical for lakes in intact status within the oligotrophic region were represented as single shoots and individuals in both of the shallow-water biotopes 10 and 16: *Carex rostrata*, *Eleocharis palustris*, *Equisetum fluviale*, *Juncus bulbosus*, *Littorella uniflora*, *Lo-*

belia dortmanna, *Myriophyllum alterniflorum*, *Pilularia globulifera*, *Ranunculus flammula* v. *reptans*, and *Subularia aquatica*. In biotope 17 Ängsjön there was a dense carpet of *Isoëtes lacustris*.

In the auxotrophicated biotopes the *Phragmites* stands were pure or intermingled with *Lemna minor*. In 12 Rolsmosjön also *Fontinalis antipyretica* occurred.

At summer normal water level the depth did not exceed 50 cm except in 17 Ängsjön where it was ca. 200 cm.

In the intact biotopes the exchange of surface water (analyses in Table 16) with the open lake (Rolsmosjön and Ängsjön) was good and the variations in water quality were small. In the auxotrophicated biotopes with dense reed-beds there were considerable variations in the water quality in connection with fluctuations in water level and in the supply of subsoil and waste water.

As the water colour in the deep-water biotope 17 Ängsjön did not seem to exceed 5 mg Pt/l during the vegetation period there were good light conditions at the bottom. The highest value found in the shallow-water biotopes was 65 mg Pt/l (15 Tiken). Probably somewhat higher values could occasionally be found in the spring.

The specific conductivity was ca. 60 μ S in 16—17 Ängsjön, i.e., slightly higher than that in the most intact Aneboda biotopes. In 10 Rolsmosjön the conductivity was ca. 70 μ S.

At high and normal water level the conductivity in 11 Rolsmosjön was slightly higher than in biotope 10 in the same lake. However, at low water

the conductivity rose to about 100 μS as the supply of subsoil water increased. For the most part the conductivity was higher than 100 μS in the other auxotrophicated biotopes.

In the light reed-beds in the intact biotopes the pH value was mostly between 6.5 and 7.0 during the vegetation period. In the auxotrophicated biotopes, above all in those polluted by sulphite lye, the reaction was much more acid.

The concentration of the analysed elements was, like the specific conductivity fairly stable in the intact biotopes.

The variations in the auxotrophicated biotopes were considerable and were due to the local conditions. Thus in 11 Rolsmosjön the concentration of K, etc. increased with decreasing water depth and the relatively greater supply of subsoil water (cf. also the soil analyses). Also at high water level there was in Rolsmosjön a noticeable difference in the surface water concentration of K between the biotopes 10 and 11. This was due to differences in the geologic conditions in the surroundings of the biotopes (cf. the note on soil fertility in the general description of the region p. 67). Also in 15 Tiken the increase in the concentration of K, Mg, Ca, and Cl in connection with decreasing water depth was probably due mainly to the relatively greater subsoil water supply.

On the other hand, in biotope 12 Linnerydssjön, where there did not seem to be any supply of subsoil water from the surroundings, there was during the vegetation period a decrease in the concentration of K, while Na, Mg, Ca, and Cl increased. The K decrease was undoubtedly caused by the uptake by the shoots of the dense *Phragmites* reed-bed.

In biotopes 13—14 the variations were due mainly to fluctuations in the supply of waste water.

The quality of the interstitial water (Table 16) was above all studied in the minerogenic bottoms in biotope 15 Tiken and 16 Ängsjön and to some degree in the gyttja bottom in 12 Linnerydssjön.

As for 15 Tiken (alternating silty and sandy/gravelly layers) a lowering of the subsoil water level was accompanied by a marked increase in the specific conductivity of the interstitial water in the superficial soil layers; the highest conductivity being 10 times that of the lowest obtained for the surface water. While the concentrations of Na, Mg, Ca, and Cl as well as the alkalinity increased with the lowering of the water level, the K content decreased during the vegetation period, probably due to uptake by *Phragmites* (for details see Table 16).

In 16 Ängsjön (sandy and gravelly soils) there was, without doubt, a supply of subsoil water. In comparison with the surface water, the interstitial water of the superficial soil layer showed approximately a twofold increase in the specific conductivity, and the analysed elements had approximately the following factors for the increase: Na 1.2, K and Ca 2, Mg 4, Cl 1.3, and total Fe 86. The factor for alkalinity was 9.

In 12 Linnerydssjön a lowering of the subsoil water level in the emerged biotope did not, as mentioned, seem to be accompanied by a supply of subsoil water from the minerogenic surroundings. When the subsoil water level in the biotope was gradually lower during the vegetation period, the specific conductivity, contrary to the conditions in 15

Tiken, remained the same or it became even somewhat lower.

The bottom analyses are exemplified in the Figs. 42, 44, 46, 48, 50, 52, 56 and 58. Minerogenic and organogenic soils are compared here.

In the minerogenic soils the lowest amounts of extractable metallic cations, viz., 15—25 meq/l, were found in the sandy and gravelly soils in 10 Rolsmosjön (all sampled layers within this range), 11 Rolsmosjön, 15 Tiken and 16—17 Ängsjön. Between ca. 30 and 60 meq/l were obtained from sandy and silty soils in 11 Rolsmosjön, 12 Linnerydssjön, 14 Hammaren, 15 Tiken, and 16 Ängsjön.

In the organogenic soils the lowest amounts of extractable metallic cations, viz. about 35—55 meq/l, were found in the gyttja in 13 Veden and 17 Ängsjön, while 60 to 100 meq/l were obtained from the gyttja in 12 Linnerydssjön and 14 Hammaren as well as from the superficial root felt layer in 15 Tiken.

The percentage of neutralization in most of the minerogenic soils was >70 %. In several soils in 15 Tiken and 16 Ängsjön it was ca. 90 % and in some layers in 11 Rolsmosjön 100 % was obtained.

In the organogenic soils the percentage figures were lower and varied from 50 to about 65 (pH in gyttja 5.7—6.2).

The lowest amount of extractable Na was found in 10 Rolsmosjön and 16—17 Ängsjön (ca. 0.4—0.6 mmol/l) and the highest in 11 Rolsmosjön, 12 Linnerydssjön and 15 Tiken (ca. 1.0—1.5 mmol/l).

Noticeably high amounts of K (ca. 1.5—3.0 mmol/l) were extracted from sandy soils in 11 Rolsmosjön and noticeably low amounts from gyttja in 14 Ham-

maren and 17 Ängsjön (<0.2 mmol/l). In the auxotrophicated biotopes 12—13 the superficial less consolidated gyttja layer contained more K than the underlying more consolidated ones.

The amounts of extractable Ca and Mg were mostly correlated with the total amount of extractable metallic cations, but in some soils Fe played an important rôle.

On equivalent basis the Ca/Mg quotient was of the order 1—2 in the biotopes 10—11 Rolsmosjön, 12 Linnerydssjön and 13 Veden (except the superficial layer), while it was 2—3 in most sampled layers in 14 Hammaren, 15 Tiken, and 16—17 Ängsjön.

The greatest amounts of extractable Fe (12—17 mmol/l) were obtained from the lower sampled levels in 14 Hammaren, from the superficial layers in 15 Tiken and from the lower layers in 16 Ängsjön.

Only a few figures concerning extractable P are available. Relatively low values were obtained in 14 Hammaren and 10 Rolsmosjön as well as in 12 Linnerydssjön and 13 Veden. However, in the last-mentioned auxotrophicated biotopes the content in the superficial gyttja was higher than in the underlying soil. Considerably greater amounts were found in 11 Rolsmosjön and 15 Tiken. In both biotopes there was a trend of downward increase.

B. *Phragmites communis*

The polyploid level of all investigated *Phragmites* clones was tetraploid (Table 17).

The percentage of apparently morphologically good pollen was only 60—65 in the clones in biotopes 10—12 but

ca. 80—85 in the clones in biotopes 13—15 (Table 17).

The late-flowering clones in 11 Rolsmosjön and 16 Ängsjön had the smallest mean diameter of the pollen, viz., 25—26 μm and the clone in 12 Linnerydssjön the largest, 29.5 μm (Table 18).

In the intact biotopes 10 Rolsmosjön and 16 Ängsjön the rhizome layer was noticeably superficially situated and in Ängsjön runners growing along the bottom occurred. In the auxotrophicated biotopes with gyttja and loose minerogenic soils the rhizosphere had the greatest vertical extension.

The shoots with the smallest dimensions occurred in the intact biotopes 10 Rolsmosjön and 16 Ängsjön where the average panicle shoot length was 125—150 cm (Table 20). On the other hand, also the longest shoots from this region, about 350 cm, were found in the group of intact biotopes, viz., in deep water in 17 Ängsjön (Fig. 59).

Among the auxotrophicated biotopes 12 Linnerydssjön, 13 Veden, and 15 Tiken were characterized by slender shoots, 200—240 cm long (PS). In 14 Hammaren the shoots were thicker and had a mean length of 240—290 cm and in 11 Rolsmosjön they reached 300 cm.

As for the shallow-water biotopes the total leaf area per panicle shoot (Table 20) was correlated with the shoot length, and thus the smallest areas were found in intact biotopes (1.0—1.6 dm^2) and the largest in the auxotrophicated ones (ca. 2—8 dm^2). The shoots in the intact deep-water biotope 17 Ängsjön had relatively short leaves gathered in the top part of the shoot and the leaf area was here only 6 dm^2 , i.e., ca. 2 dm^2 smaller than the 50 cm shorter shoots in 11 Rolsmosjön.

The length of the stomatal guard-cells of the middle shoot leaves was $< 24 \mu\text{m}$ and the density of stomata > 1000 in all clones (Table 19).

The shoot density in the intact biotopes was 15—25. Among the auxotrophicated biotopes the density was 50—75 in 11 Rolsmosjön and 14 Hammaren, about 100 in 15 Tiken and 130 in 12 Linnerydssjön and 13 Veden.

Low as well as fairly high panicle frequencies were observed in the intact biotopes as the frequency was within the range 5—35 % in biotopes 10 Rolsmosjön and 17 Ängsjön but 65 % in 16 Ängsjön. In the auxotrophicated biotopes 11 Rolsmosjön, 13 Veden and 14 Hammaren the frequency was ca. 65—75 %. Especially in those biotopes in which the water depth was more or less great in some years but the bottom could be emerged in others, the variations in panicle frequency were great. So in 12 Linnerydssjön the greatest variations observed were from 40 to 70 % and in 15 Tiken from 0 to ca. 50 % (p. 84 and Fig. 51).

In years with low water level in the lakes the earliest flowering occurred in 15 Tiken and the latest, about one month later than in Tiken, in 16 Ängsjön. In years with high water level the flowering was retarded in all lakes but the time difference between the clones was smaller.

The leaf area per m^2 (Table 20) at the time of flowering was about 10—15 dm^2 in the intact shallow-water biotopes 10 Rolsmosjön and 16 Ängsjön, but about 100 dm^2 in the deep-water biotope 17 Ängsjön.

In the auxotrophicated biotopes the leaf area was within the range 200—400 dm^2/m^2 in 15 Tiken, 12 Linneryds-



Fig. 59. Panicles and shoots from biotopes in the Veden-Tiken-Ängsjön region. The biotope 15 panicles from 1963 and 1964; the shoots from 1963 (PS and WPS). Biotope 17 represented by four different shoots, all from 1963.

TABLE 16. Water analyses.

TABLE 19. Biometric analyses of stomata

TABLE 20. Biometric analyses of shoots.

TABLE 24. Environmental conditions at samplings, description of samples for sap expression and analyses of whole samples, press-cakes and expressed sap.

*1 = panicles grown out to 50 %. *2 = no flowering panicles in the sample.

sjön and 11 Rolsmosjön and reached its highest value, viz., 600 dm²/m² in 13 Veden.

The standing crop (Table 22) was correlated with the leaf area/m². The lowest values, about 50 g/m², were obtained from the intact shallow-water biotopes 10 and 16, and the highest, ca. 1400 g/m² from biotope 13. For 14 Hammaren the figures were of the same magnitude as in 12 Linnerydssjön.

The analyses of expressed sap and press-cakes (Tables 23—24) are discussed in the Synthetic Part and therefore only some notes are given here.

The rhizome sap from 11 Rolsmosjön had the highest summer concentration

of K and — though the difference from other biotopes was small — also of Cl.

In the analyses of sap from the lower leaves the differences are most striking between 15 Tiken with high and 16—17 Ängsjön with low concentrations of Na and K at a comparable stage of development. However, between the Ängsjön biotopes the differences in the content of Ca and Mg were considerable.

The differences found in the lower leaves had no correspondence in the upper and relatively younger leaves. In these the amounts of Na and K were about the same in Tiken and Ängsjön and no noteworthy divergences were found in the Mg and Ca concentrations between the Ängsjön biotopes.



III. Biotopes in the Orlunden–Norjesund Region

General Description of the Region

All biotopes of this region are located in waters belonging to the watercourse system of the streams Western and Eastern Orlundsån (Fig. 60). Both streams drain Lake Orlunden, run parallel to the south and empty into the bay Pukaviksbukten of the Baltic.

Geologic and geographic surveys are given by BJÖRNSSON (1936, 1946), NORIN (1936) and LARSSON (1954). In the main part the bedrock consists of Archaean rocks which to some degree have a favourable influence on the soils. However, in the southern part there are Cretaceous rocks with favourable influence on the soils (Fig. 61).

The highest shore line is at about 55–60 m a.s.l. (Fig. 5 E). Above this, i.e., especially around the lakes Vitavatten, Orlunden and Vångasjön, the loose earth covering consists of Archaean moraine. The higher parts of the area below the highest shore line are covered by washed moraine, while the lower parts are characterized by fine-grained,

often sandy soils. In the southwestern part the soils within the area of the former Lake Vesan (about 15 km²) consist of gyttja, largely deposited in marine environment (BJÖRK 1957).

Broadly speaking, the moraine areas are covered by forests of beech (*Fagus silvatica*), spruce (*Picea abies*) and mixed broad-leaved coniferous forests with oak (*Quercus robur*), birch (*Betula pubescens*, *B. verrucosa*), spruce and pine (*Pinus silvestris*). To a great extent the fine-grained soils of the valleys are cultivated.

The outlets of the lakes Vitavatten, Vångasjön and Orlunden have been deepened and the water level lowered. The cultural influence on Eastern and especially Western Orlundsån is strong. Until 1958 Western Orlundsån served as recipient for the sewage from 1 dairy, 2 distilleries and 5 starch factories (cf. BJÖRK 1956) and Eastern Orlundsån for 1 starch factory.

Due to the fact that the production of the starch factories and distilleries is restricted to the autumn and early winter, an alternation between heavy pollution during the working season and no or fairly weak pollution during the

Fig. 60. Topographical map of the Orlunden–Norjesund region. The location of biotopes 18–29 indicated by numbers. Top left the market town Olofström. Compare Fig. 4.



Fig. 61. Rocks of the Orlunden-Norjesund region: 1. Hälleflinta. 2. Gneiss. 3. Quartzites and schists. 4. Cretaceous rocks. 5. Gneiss-granite. 6. Granite. 7. Amphibolite. 8. Diabase. (Redrawn from Norin 1936.)

rest of the year has characterized the limnologic conditions in especially the middle and lower parts of Western Orlundsån (Björk op.c.).

Originally Western and Eastern Orlundsån discharged their water into Vesån, which gradually became more isolated from the Baltic. In the 1850's Eastern Orlundsån was connected directly with the Baltic and in the 1860's (partly) and 1920's (definitely) the communication of Western Orlundsån with Vesån was cut off and the water con-

ducted directly to Norjesund, the original outlet to the Baltic for the whole drainage area. These measures were made in connection with the walling in and drainage of Vesån, which in 1926—1934 was laid dry. Waste water from a starch factory and a distillery is also discharged in the drainage system of Vesån.

Due to natural conditions and cultural influence there is a downstream increase in the specific conductivity of the water in the streams. The pollution of the rivers during the working season of the factories was indicated by, e.g., high KMnO_4 -consumption and low oxygen saturation (Table 27).

There are small but distinct climatic diversities between the upper and lower parts of the region. During the investigation period 1955—1966 the meteorologic conditions have shown fairly great differences between the different vegetation periods (Fig. 62).

Lake Vitavatten

With Biotope 18

General Description

56°15'N, 14°35'E. Altitude 69 m a.s.l. Area 0.4 km². Max. depth 25 m.

The topography and geology around Lake Vitavatten have been described by Björns-son (1936) and vertical oxygen and temperature investigations in the lake have been made by Alsterberg (1927).

The lake is a rock basin formed by ice excavation of the intersection of two shatter belts in coarse-grained granite. With some few exceptions the shores are minerogenic. The surroundings are covered by forests and only a couple of summer houses are situated in the vicinity of the lake. The lowering of the water level (the outlet deepened) has probably not exceeded 1 m. Since 1959 the lake has served as a reservoir for the central

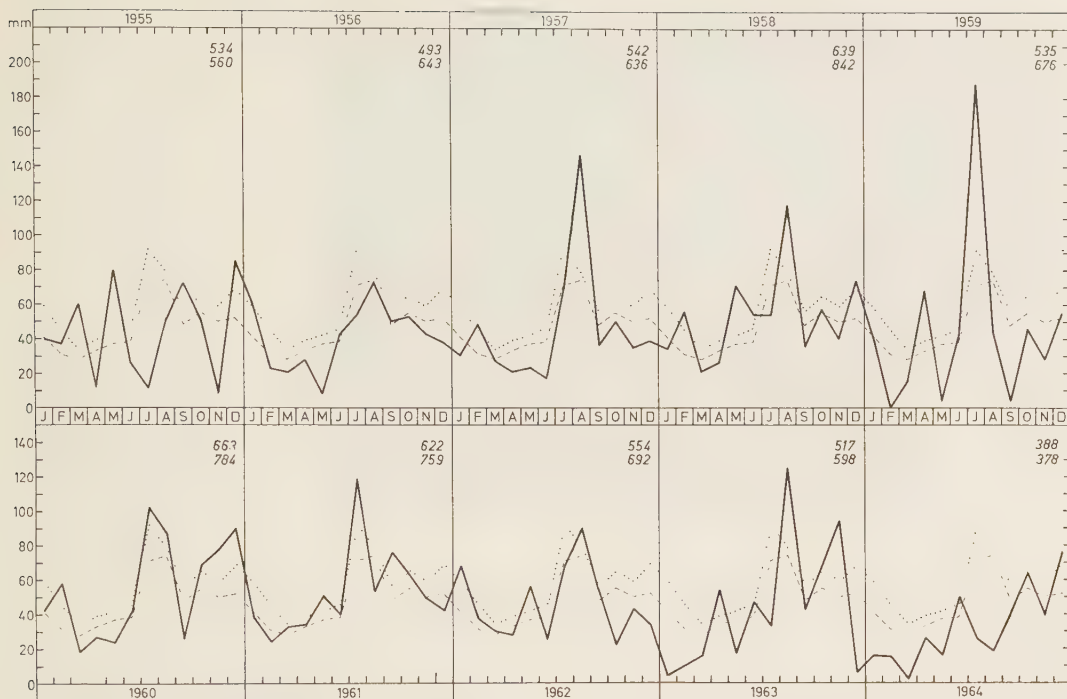


Fig. 62. Precipitation per month in Norjeby (solid line) and monthly mean precipitation for the period 1950–1964 in Norjeby (broken line) and Olofström (dotted line). Top right figures for early precipitation in Norjeby (above) and Olofström (below). Norjeby situated at Norjesund and Olofström ca. 5 km east of Lake Orlunden. Compare Figs. 60 and 61.

potato starch factory at Gränum. This has resulted in greater water level fluctuations than earlier. In 1962 Vitavatten was treated with rotenone.

The water is oligohumic and highly transparent. Data on water from the pelagic superficial layer (samplings in Aug., Sept., Oct., Nov. 1955, May, Sept., Oct. 1956): Tr 590–720, $m=650$, Col 0–5, $KMnO_4$ -cons. 12–25, $m=20$ mg/l, Sp. cond. 52–54, $m=53$ μS , pH 6.5–7.3, $m=6.8$, Cl 230–280, $m=250$ $\mu mol/l$, and $(O_2)s$ 86–110, $m=96$ %.

The hyperhydate, ephydate and elodeid vegetation is very sparse and consists of single small and very scattered stands of *Carex rostrata*, *Eleocharis palustris*, *Equisetum fluviatile*, *Juncus bulbosus*, *Lysimachia thyrsiflora*, *L. vulgaris*, *Myriophyllum alterniflorum*, *Nuphar luteum*, *Nymphaea alba*, *Phragmites communis* and *Scirpus lacustris*.

The macrophyte vegetation is characterized by the isoetids. Dense carpets of *Lobelia*

dortmanna cover minerogenic and organogenic bottoms below the erosive littoral zone. Quantitatively richly represented are also *Littorella uniflora*, *Isoetes lacustris*, *Ranunculus flammula* v. *reptans* and *Subularia aquatica*. In the dense isoetid carpets *Nostoc Zetterstedtii* was found.

With respect to the characteristic features of the macrophyte vegetation Vitavatten is classified as a *Lobelia*-lake (SAMUELSSON 1925, pp. 7–8).

Biotope 18

A. Environment

Situation (Fig. 63). In a small creek in the western bay.

Physiographic survey (Fig. 63). The innermost part of the creek consists of a *Sphagnum* fen with *Carex rostrata*, *Drosera*



Fig. 63. Biotope 18 Vita-
vatten. — Photo S. Björk
620906.

rotundifolia, *Menyanthes trifoliata*, *Myrica gale*, *Phragmites communis*, and, in the fen/lake margin, *Nuphar luteum*. Investigations have been made only on *Phragmites* growing in the lake outside the fen.

The biotope is overshadowed in early morning and late afternoon. It is sheltered against winds and no wave action is noticeable.

Besides *Phragmites* the macrophyte vegetation consisted of single shoots of *Carex rostrata*, *Equisetum fluvatile* (stems without or with only a few branches), *Juncus bulbosus* and small-leaved non-flowering *Nymphaea*.

The water (Table 26). The noted water depths varied between 5 and 50 cm during the vegetation periods in the years 1956—1965.

At high and normal summer water level in the lake the surface water in the biotope is of about the same quality as the superficial pelagic water. During periods with low water level the quality of the biotope water is influenced by the inflow from the *Sphagnum* fen. As a result of this the water becomes richer in electrolytes and more acid.

At different water levels the following

data were obtained (number of analyses in parentheses).

Water depth 35—50 cm: Col 5 (1), Sp.cond. 53—54 μ S (3), pH 6.2—6.7 (3), Na 190 (1), K 15 (1), Mg 40 (1), Ca 100 (1), Fe 1 (1), Cl 195—230 μ mol/l (2), and Alk 48 μ eq/l (1).

Water depth 20—30 cm (2 samplings except P): Col 25—55, Sp.cond. 70—72 μ S, pH 4.7—5.3, Na 250—260, K 13—17, Mg 70, Ca 120—140, Fe 4—6, Cl 215—240, P 0.3 μ mol/l (1), and Alk < 0.

In interstitial water (suction of fresh soil) only Cl was analysed. Down to 125 cm the content was about the same or only somewhat higher than in the surface water.

The bottom (Fig. 64). Down to 125 cm the substratum, with the exception of one somewhat deviating layer, was a typical drift gyttja, partly of a rough structure with cones and bark of *Pinus* and rich in wood. In the upper 70 cm cyperaceous radicels were frequent and also rhizomes of *Equisetum* occurred. Between 44 and 63 cm the frequency of radicels was high. The up-

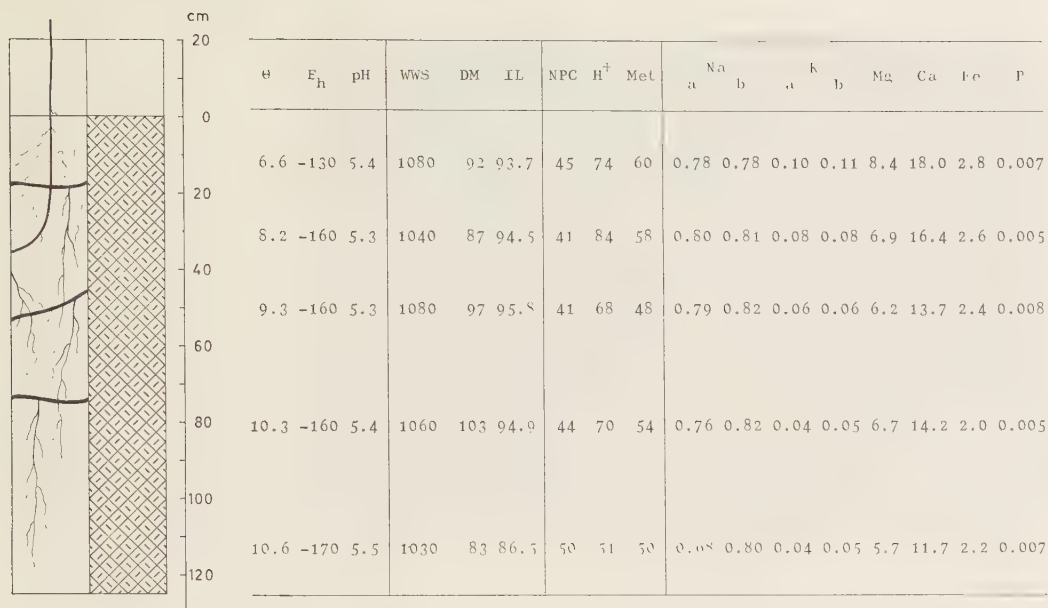


Fig. 64. Biotope 18 Vitavatten 631122. Vertical section and soil analyses.

per 5 cm was very loose and had a black-brown colour. Below 5 cm the soil was brown.

With respect to the analysed properties the gyttja was rather homogeneous. It was characterized by low percentage of neutralization and low content of extractable K and especially P.

B. *Phragmites communis*

Rhizomes and roots (Fig. 64). Horizontal rhizomes occurred from 10 to 70 cm. Especially in the superficial soil layers the rhizomes were affected by *Donacia*. The lowest noted level for thick roots (cut off) was 113 cm. Only in a few cases were roots observed on the basal shoot nodes.

Shoot density. Ca. 2. The distribution was uneven; up to 10 shoots per m² occurred.

Flowering time. In 1961 the development of the panicles was slow and poor and in 1962 no flowering panicles were observed. In earlier years

the flowering occurred in the second to third week in Sept.

Panicle frequency. 25 % in 1961, < 1 % in 1962.

Further data in Tables 28—34.

Lake Vångasjön

With Biotopes 19—21

General Description

56°17'N, 14°38'E. Altitude 66 m a.s.l. Area 0.1 km². Max. depth 2.5 m.

The shallow lake is surrounded in the north by cultivated ground and pastures, but for the rest by mainly broad-leaved forests. The water level has been lowered and due to this the sediments reach the water surface along the shores.

The water is oligohumic. As the lake has a sheltered position and the macrophyte vegetation is spread over the whole bottom surface, the superficial sediments are not whirled up to any greater extent. On all observation occasions the transparency was greater than the depth of the lake. Data on the quality of pelagic water from the super-



Fig. 65. Lake Vångasjön. Biotope 19 in the left part of the *Phragmites* stand. Biotope 20 located in the continuation of the reed-bed towards the right. — Photo S. Björk 630919.

ficial layer (samplings in Sept., Oct., Nov. 1955, May, Sept., Oct. 1956): Col 5—15, KMnO_4 -cons. 33—52, $m=44$ mg/l, Sp. cond. 80—90, $m=85$ μS , pH 6.8—6.9, Cl 340—390, $m=370$ $\mu\text{mol/l}$, and $(\text{O}_2)_s$ 80—110, $m=96$ ‰.

The lowering of the water level has resulted in a quantitatively rich development of the macrophyte vegetation. Vångasjön is nowadays characterized by expanding reeds of *Equisetum fluviatile*, *Phragmites communis*, and *Scirpus lacustris* and large stands of *Carex lasiocarpa* and *Carex rostrata*. The outer border of the expanding reeds is formed by *Equisetum fluviatile*. Within an observation reach in the eastern part of the lake the front of the *Equisetum* belt has expanded about 15 m lakewards during the period 1955—1965. Over practically the whole lake there are dense or more scattered stands of *Potamogeton natans*, *Nuphar luteum* and *Nymphaea alba*. *Lemna minor* occurs shorewards from biotope 19. The bottom is covered by mats of *Nitella* and *Juncus bulbosus*. *Isoetes lacustris*, *Littorella uniflora* and *Lobelia dortmanna* are represented but are quantitatively very weakly developed.

Broadly speaking, Vångasjön is a typical example of a shallow south Swedish lake in which the macrophyte production has increased vigorously after lowering of the water level.

Biotope 19

A. Environment

Situation (Fig. 65). Outside the middle reach of the north shore.

Physiographic survey (Fig. 65). The distance from the shore (E—W direction) to the biotope was about 8 m. Above the shore there was pasture land with scattered birches and outside the biotope there were expanding stands of *Carex rostrata*, *Equisetum fluviatile* and *Scirpus lacustris*. The biotope was sheltered against winds and no wave action was noticeable. In a 1 to 2 m broad zone with open water shorewards from the reed-bed the surface was often covered by *Lemna minor*. In the biotope the *Phragmites* stand was pure.

The dry *Phragmites* stems remained for one and partly for two years.

The water (Table 26). The water depth varied from 0 to ca. 50 cm on observation occasions during the vegetation periods in 1962—1964.

At water depths varying from 20 to 50 cm the following surface water quality data were obtained (samplings in Aug., Sept., Oct. 1962, May, June, Aug., Sept., Oct. 1963, Oct. 1965; number of analyses in parentheses): Col 25—45,

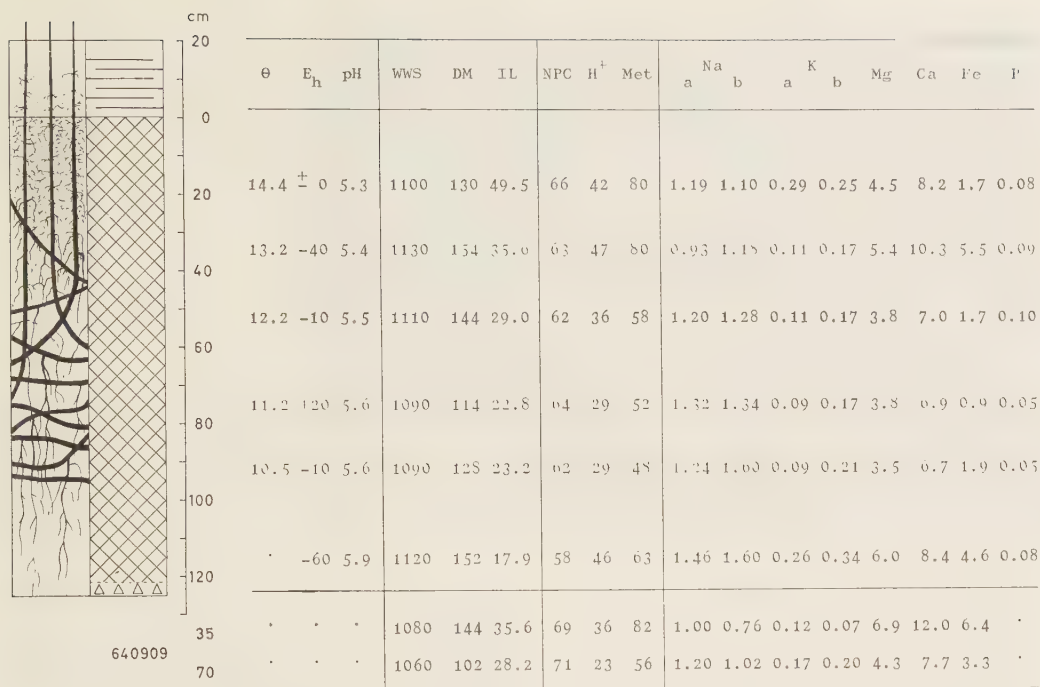


Fig. 66. Biotope 19 Vångasjön. Vertical section and soil analyses from 630805 and 640909.

$m=30$ (6), Sp.cond. 78—120, $m=90$ μS (9), pH 6.0—6.7, $m=6.4$ (9), Na 270—330, $m=300$ (6), K 20—39, $m=30$ (5), Mg 80—120, $m=100$ (4), Ca 170—250, $m=210$ (6), Fe 4—6 (2), Cl 340—370, $m=350$ $\mu mol/l$ (8), and Alk 170—416, $m=258$ $\mu eq/l$ (5).

Interstitial water obtained by suction of fresh soil from a vertical section in Aug. 1963 (water depth 20 cm) had a conductivity which was about twice that of the surface water. The content of K in the interstitial water was lower in the lower part of the section than in the surface soil layers, while the concentration of Cl showed a weak increase downwards. In a sample from Sept. 1964, taken in a 18 cm deep pit (water level -7 cm) the content of K was about two times as great as in 1963.

The bottom (Fig. 66). The surface covered by 15 cm *Phragmites* litter.

Stratigraphy:

- 0—12 cm Coarse gyttja (*Phragmites detritus*).
- 12—105 cm Dark brown gyttja.
- 105—122 cm Dark olive-green gyttja.
- 122—125 cm Sandy moraine.

With respect to the analysed properties the gyttja was fairly homogeneous throughout the section. There was, however, a rise in the E_h values in the layers of highest rhizome frequency. While the percentage of neutralization was about 60 % at all levels, there was a decrease in the amount of extractable cations around and somewhat below the middle part of the section. The amount of Na and K increased downwards with the exception of the uppermost layer.

B. *Phragmites communis*

Rhizomes and roots (Fig. 66). The horizontal rhizomes were concen-

trated as deeply as between 50 and 95 cm. Thick roots occurred down to the minerogenic soil. Fine roots developed from the vertical rhizomes were remarkably frequent between 5 and 30 cm. Here they constituted a thick tough felt. As a rule the stems had roots on 2 to 3 basal nodes.

Shoot density. Ca. 45.

Flowering time. In the second to fourth week in Sept.

Panicle frequency. 90 %. The panicles were characterized by being very well developed. The frequency of dry, sterile and deformed panicles was only 2 %. During the years 1962—1964 the panicle frequency was quite constant.

Further data in Tables 28—35.

Biotope 20

A. Environment

Situation (Fig. 67). 50 m east of biotope 19, in the center of a wide bay, about 40 m from the shore.

Physiographic survey (Fig. 67). As for exposition etc. cf. biotope 19 (p. 100). The whole bay was overgrown with *Phragmites* and *Carex rostrata*. During the observation period the latter species dominated in the outer part where it outwards was successively replaced by *Equisetum fluvatile*. In the outer part of the bay and along the shore the hyperhydrites were rooted in the undisturbed sediments. In the main part of the bay the superficial bottom layer, interwoven with roots and rhizomes (above all of *Phragmites*), had risen towards the water surface. The biotope was situated in the central part of this area with plaur-like formations. Here and there small areas of one or a few m² of the superficial bottom layer had risen dome-shaped above the water surface. When the raised layer was punctured, gas often escaped. Formations of this kind are rather common in overgrown, lowered, shallow lakes in South Sweden

(BJÖRK 1962 a). The emerged bottom areas were the biotopes in which *Carex rostrata* and *Phragmites communis* from a quantitative point of view showed their best development in the bay with plaur-like formations in Vångasjön. In an area like this there are rapid alternations in the physiographic conditions.

In the biotope the raised superficial bottom layer was even, i.e., no dome-shaped formations occurred during the investigation period 1962—1964.

The *Phragmites* stand in the biotope was almost pure, only a few scattered shoots of *Carex rostrata* occurred. Some few individuals of *Potentilla palustris* and *Sparganium minimum* were also found.

The dry *Phragmites* stems usually remained for one vegetation period.

The water (Table 26). In the years 1962—1965 the water depth varied from 0 to 45 cm during the vegetation period.

The surface water quality was much the same as in biotope 19. Due to the greater distance from the shore there were, however, in biotope 20 not as great and sudden alternations as in biotope 19. At water depths varying between 15 and 45 cm the following surface water quality data were obtained (samplings in Sept., Oct. 1962, May, June, Aug., Sept., Oct. 1963, Nov. 1965; number of analyses in parentheses): Col 20—45, m=30 (5), Sp. cond. 83—93, m=89 μ S (8), pH 6.2—6.7, m=6.4 (8), Na 280—350, m=300 (6), K 14—42, m=29 (6), Mg 60—80, m=70 (5), Ca 180—250, m=200 (6), Fe 3 (1), Cl 345—395, m=365 μ mol/l (8), and Alk 210—250, m=228 μ eq/l (5).

The interstitial water quality showed rather great differences in comparison with biotope 19. Interstitial water was obtained partly by suction of fresh soil samples from a vertical section (Aug. 1963, water depth 15 cm) and partly from a dug pit (Sept. 1964, water level

Fig. 67. Biotope 20 Vångasjön. Biotope 19 located in the continuation of the reed-bed towards the left.
— Photo S. Björk 630919.



--4 cm, pit depth 15 cm). The water from the section had a very dark colour, viz., up to 900 mg Pt/l. In the layers with dark-coloured water the amount of total iron was remarkably high. There was downwards an increase with respect to Mg, while the concentrations of Na, Cl and (with exception of the lowermost level) K decreased in the same direction.

In comparison with the quality of the interstitial water from the corresponding soil layer in the vertical section taken in 1963, the water sampled in 1964 in the dug pit had lower colour values and lower total iron content.

The bottom (Fig. 68). The upper 30—40 cm consisted of brown gyttja, very densely interwoven with fine *Phragmites* roots. Below this and down to 150 cm there was brown gyttja which in its lower part was fairly well consolidated. Upwards it became, however, more and more loose and watery and probably there was at about the 50 cm level a layer with water.

Below the superficial *Phragmites* root felt and down to ca. 105 cm dead rhizomes and roots of *Equisetum fluviatile*

were frequent and roots of this species were found down to 140 cm. It is characteristic of the lake that reeds of *Equisetum fluviatile* constitute the lake-ward margin of the hyperhydate border. Obviously the *Equisetum* front has passed also the biotope before it was occupied by *Phragmites*. The distance between the biotope and the landward limit of the *Equisetum* reed belt was in 1963 30 m.

A slight tendency of downwardly increasing values for pH and percentage of neutralization was noticeable. On the other hand, the extractable amounts of cations decreased downwards. As for K there was a clear concentration gradient with the lowest values below.

B. *Phragmites communis*

Rhizomes and roots (Fig. 68). Horizontal rhizomes were found from 40 cm, i.e., the lower part of the superficial root felt, down to 95 cm. The vertical rhizomes, part of which were as long as 70—80 cm, were fairly richly

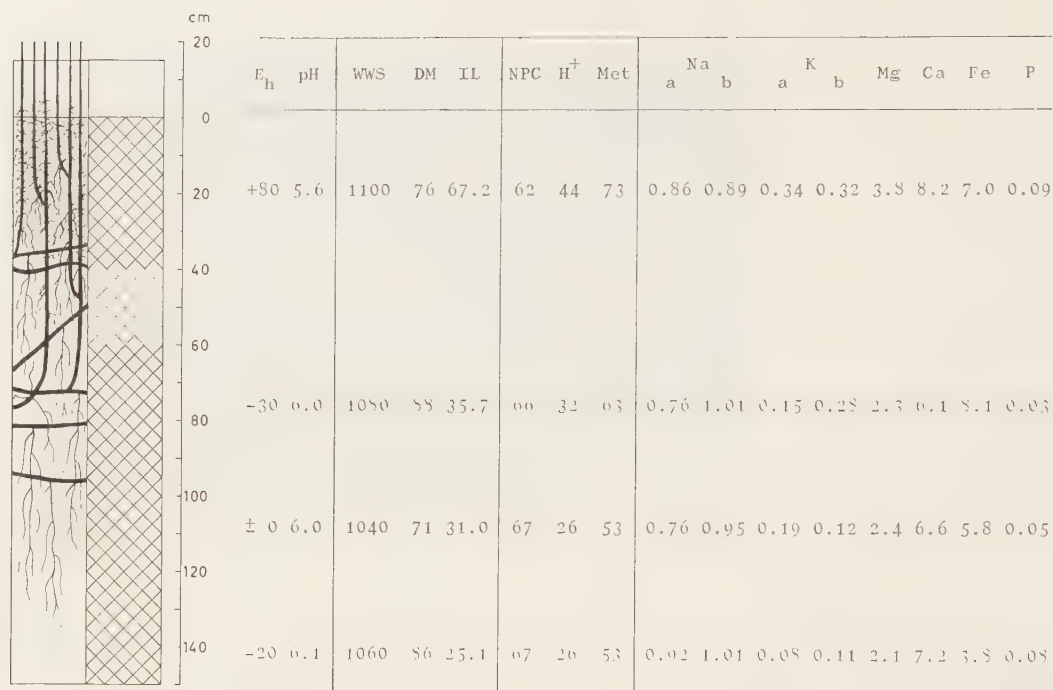


Fig. 68. Biotope 20 Vångasjön 630805. Vertical section and soil analyses.

branched, especially in the raised superficial bottom layer, a typical feature in a biotope with the plaur-like conditions prevailing here (cf. also biotope 13 Veden, p. 78). Thick roots were found down to 140 cm. The frequency of fine roots from the vertical rhizomes in the superficial layer was very high. The tough root felt was capable of sustaining the weight of a man. Only about half the number of shoots had roots on one to two basal nodes.

Shoot density. Ca. 95.

Flowering time. In years when the biotope was submerged during the summer and autumn the flowering occurred as late as in the last week in Sept. or sometimes even later. If, on the other hand, the bottom was emerged during the mentioned period, the flowering occurred about two weeks earlier. Concerning Vångasjön the water level

fluctuations in the main also reflect the precipitation (weather) conditions.

Panicle frequency. Within the whole plaur-like area the panicle frequency was low, on an average 10 %. The frequency of dry, sterile and deformed panicles was as high as 55 %.

Further data in Tables 28—31, 33—35.

Biotope 21

A. Environment

Situation. In the eastern part of the lake, about 40 m lakewards from the shore.

Physiographic survey. Between the shore and the biotope there were reeds of *Phragmites* which towards the shore became intermingled with *Carex lasiocarpa* and *C. rostrata*. Towards the lake there was a broad *Equisetum fluviatile* belt. The biotope was fairly sheltered against winds and no wave action was noticeable.

Besides *Phragmites* the species *Carex rostrata*, *Equisetum fluviatile* and *Scirpus lacustris* were represented by a few shoots in the biotope at the beginning of the investigation period 1956—1965. The bottom was then overgrown by *Nitella*. The intermingling with *Carex* has gradually become more accentuated. Rhizome and root remnants in the sediment indicated the earlier passing of the *Equisetum* belt.

The water (Table 26). On the observation occasions during the vegetation periods in 1956—1965 the water depth varied from 25 to 75 cm. The mean depth during the flowering time was 55 cm.

Analyses of surface water (samplings in Aug., Sept. 1962, Oct. 1965; number of analyses in parentheses): Col 20 (2), Sp.cond. 88—110, $m=98\ \mu\text{S}$ (3), pH 6.5—6.7, $m=6.6$ (3), and Cl 360—370 $\mu\text{mol/l}$ (2).

The bottom. Below a 5 cm layer of coarse detritus the soil consisted of brown gyttja, which in the upper 20 cm was intermingled with coarse material. Below 65 cm the brown gyttja was very loose.

B. *Phragmites communis*

Rhizomes and roots. Horizontal rhizomes occurred particularly between 25 and 65 cm, the main part in the lower half of this layer. Thick roots were found down to 114 cm (cut off). The fine roots from the vertical rhizomes constituted a thick tough felt between 5 and 25 cm. Fine roots were common between 25 and 65 cm. Also the thick roots penetrating deeper soil layers were richly set with fine roots. The frequency of roots on the basal shoot nodes was low.

Shoot density. Ca. 75 (about 1960).

Flowering time. Second to third week in Sept.

Panicle frequency. In 1961 17 %.

Further data in Tables 28—32, 34.

Lake Orlunden

With Biotopes 22—23

General Description

56°16'N, 14°36'E. Altitude 56 m a.s.l. Area 1.7 km². Max. depth 25 m.

The topographic and geologic conditions in the Orlunden area have been described by BJÖRNSSON (1936, 1946). Information about the occurrence of lake ore, transparency (430 cm), and lake colour (yellow) from July 1936 are given by THUNMARK (1937).

The rock basin was formed by ice excavation of the intersection area of shatter belts in the boundary zone between coarse-grained granite, gneiss-granite and gneiss. To a small extent Orlunden is considered to be moraine-dammed (BJÖRNSSON 1936). The shores are minerogenic. The depth in the main part of the lake does not exceed 10 m, and especially the southern part is shallow, less than 5 m. The main part of the surroundings are covered by mixed broad-leaved coniferous forests. To the north and northeast there is some cultivated ground.

The water level has been lowered and is now regulated by dams in the two outlets. One of the main feeder streams, Gaslundaån, was earlier regularly heavily polluted from a potato starch factory during the autumn and winter. However, this factory, situated 4 km upstream from Orlunden, has been closed since 1958.

Data on the quality of water from the pelagic superficial layer south of the central part of the lake (samplings in Aug., Sept., Oct., Nov. 1955, May, Sept., Oct. 1956): Tr 310—470, $m=370$, Col 10—30, $m=20$, KMnO_4 -cons. 32—57, $m=48\ \text{mg/l}$, Sp. cond. 79—92, $m=84\ \mu\text{S}$, pH 6.4—7.2, $m=6.8$, Cl 310—370, $m=350\ \mu\text{mol/l}$, and $(\text{O}_2)s$ 81—104, $m=92\ \%$.



Fig. 69. Biotopes 22 (closest to the shore) and 23 Orlunden. — Photo S. Björk 630911.

The lowering of the water level has resulted in an increase in the quantitative development of the hyperhydate vegetation. In southern Orlunden *Carex rostrata*, *Equisetum fluviatile*, *Scirpus lacustris* and also *Phragmites communis* are the most prominent species, forming fairly large and, here and there, rather dense stands on organogenic bottoms in sheltered shore reaches. There are, however, also considerable reaches of stony shores without or with very sparse hyperhydate vegetation. *Nuphar luteum*, *Nymphaea alba*, and *Potamogeton natans* are common, especially in the south part, but the most characteristic species in the ephydate vegetation is *Sparganium Friesii*. In the hyphydate vegetation the elodeids are represented by mainly *Myriophyllum alterniflorum* and the isoetids by *Isoetes lacustris*, *Littorella uniflora*, *Lobelia dortmanna*, *Ranunculus flammula* v. *reptans* and *Subularia aquatica*. Very dense isoetid carpets are common and are above all formed by *Littorella uniflora*.

Biotopes 22—23

A. Environment

Situation (Fig. 69). Outside the western shore, ca. 500 m north of the outlet of Western Orlundsån. Biotope 22 was

situated above and biotope 23 below the sediment limit. Distance (perpendicular to the shore line) between the biotopes ca. 4 m.

Physiographic survey (Fig. 69). Above the shore (N—S direction) the steeply rising ground was covered by broad-leaved forest. Along the shore there was a dense bush curtain, typical for lowered lakes, between the shore barricade and the water line, consisting of *Myrica gale*, *Rhamnus frangula* and *Betula* bushes. Also *Osmunda regalis* occurred here.

The biotopes were overshadowed from early in the afternoon. They were exposed to easterly winds, but the wave action was weak.

Above the sediment limit there were besides *Phragmites* scattered individuals or small stands of *Carex rostrata*, *C. vesicaria*, *Eleocharis palustris*, *Glyceria fluitans*, *Lobelia dortmanna*, *Lysimachia thyrsiflora*, *L. vulgaris*, and *Myosotis palustris*. *Fontinalis antipyretica* grew on the stones. Below the sediment limit there was a fairly dense carpet of *Lobelia dortmanna* and *Littorella uniflora*, here and there with *Ranunculus flammula* v. *reptans*. Scattered individuals of *Alisma plantago-aquatica* and *Juncus bulbosus* also occurred, mainly on organogenic bottom, and *Equisetum fluviatile* on both minerogenic and organogenic bottoms.

The dry *Phragmites* stems were regularly broken in the spring.

The water (Table 26). The noted water level fluctuations amounted to ca. 100 cm during the vegetation periods in 1955—1964. The water depth of the mean part of the minerogenic zone (with biotope 22) varied between 0 and 75 cm. The summer normal water depth was ca. 20 cm. Occasionally the water level sank below the sediment limit, but biotope 23 was never emerged. At summer normal water level the depth was here ca. 80 cm.

Water quality data (samples of surface water taken between the biotopes in Sept., Oct. 1962, Sept., Dec. 1963, Aug. 1964; number of analyses in parentheses): Col 20—50 (2), Sp.cond. 75—83, $m=78\ \mu\text{S}$ (5), pH 6.3—7.0, $m=6.7$ (5), Na 250—260, $m=250$ (3), K 41—42 (3), Mg 60—80, $m=70$ (3), Ca 170—190, $m=180$ (3), Fe 2—9 (2), Cl 270—295, $m=285$ (4), P $0.3\ \mu\text{mol/l}$ (1), and Alk 76—102 $\mu\text{eq/l}$ (2). The lowest conductivity values were obtained during periods with high water level and the highest during low water periods.

In biotope 22 interstitial water was sampled: 1) through suction of fresh soil samples from three levels in a vertical soil core taken in Dec. 1963 (water depth 65 cm), 2) in a 35 cm deep pit dug in the emerged bottom in Aug. 1964.

In biotope 23 interstitial water was obtained through suction of fresh gyttja samples from a core taken in Dec. 1963.

The specific conductivity of the interstitial water was markedly higher in the minerogenic than in the organogenic soil. In the minerogenic bottom (biotope 22) the conductivity increased from 110 μS in 5 cm to 210 μS in 30 cm (as for vertical variation in grain fractions cf. below), while the conductivity of the interstitial water in the gyttja (biotope

23) was about the same at all sampled levels and not considerably higher than in the surface water. Among the analysed elements, e.g., K, Mg and Fe showed noticeably higher concentrations in the sample taken in August from the dug pit in the minerogenic bottom than in the December samples from the outer biotope (23). In the gyttja interstitial water the Cl content was practically the same as in the surface water. In the interstitial water suctioned from the minerogenic soil core taken in the submerged biotope 22 during the winter the Cl concentration was considerably higher than in the surface water. In the interstitial water sampled in the pit dug in the emerged bottom during the vegetation period, the Cl concentration was, however, markedly lower than in the surface water.

The bottom (Figs. 70 and 71). The bottom surface forms a gentle slope lakewards above the sediment limit. At this, however, the minerogenic bottom slopes steeply downwards, while the surface of the sediments constitute an even continuation of the shoreward minerogenic bottom slope. Thus there is a fairly sudden and distinct change from minerogenic (biotope 22) to organogenic (biotope 23) substratum.

In biotope 22 the bottom surface was stony.

Stratigraphy in biotope 22:

- 0—15 cm Ferruginous, stony and gravelly sand, in the lower part with fine sand.
- 15—48 cm Grey sand, here and there layers with fine sand.
- 48—70 cm In the upper part grey sand. Downwardly increasing amount of fine sand and silt and transition into a hard soil.

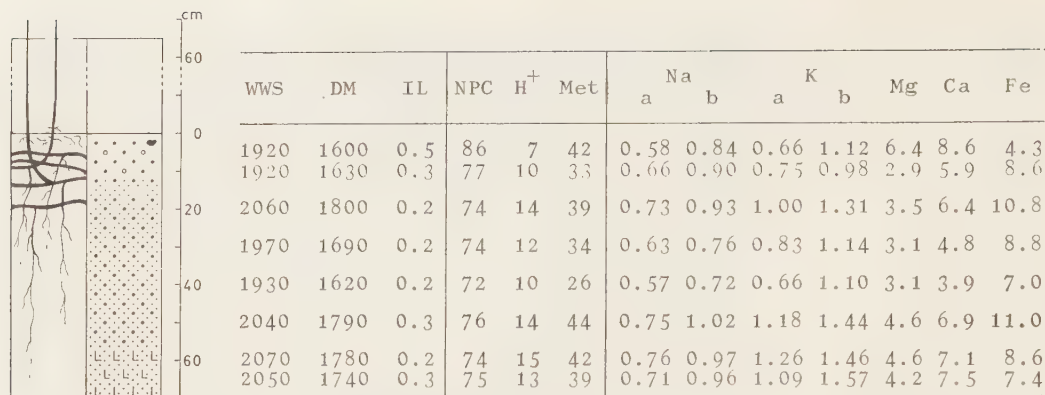


Fig. 70. Biotope 22 Orlunden 631212. Vertical section and soil analyses.

In the soil analyses the fine-grained soils are recognized through somewhat higher content of extractable metallic cations, e.g., K and Ca.

Stratigraphy in biotope 23:

Down to 75 cm the soil consisted of a loose, adhesive, dark brown, coarse gyttja, here and there containing pieces of bark and wood. Dead *Equisetum* rhizomes and roots occurred sparsely.

The percentage of neutralization was about the same in both the minerogenic and the organogenic soil, but in the

organogenic soil the obtained amounts of extractable cations were about twice as high as those for the minerogenic soil. The content of extractable Na was about the same in both soils, K showed decidedly lower values in the gyttja, but Mg as well as Ca here had the highest concentrations.

B. *Phragmites communis*

Rhizomes and roots (Figs. 70 and 71). In biotope 22 horizontal rhizomes were most common between 5 and

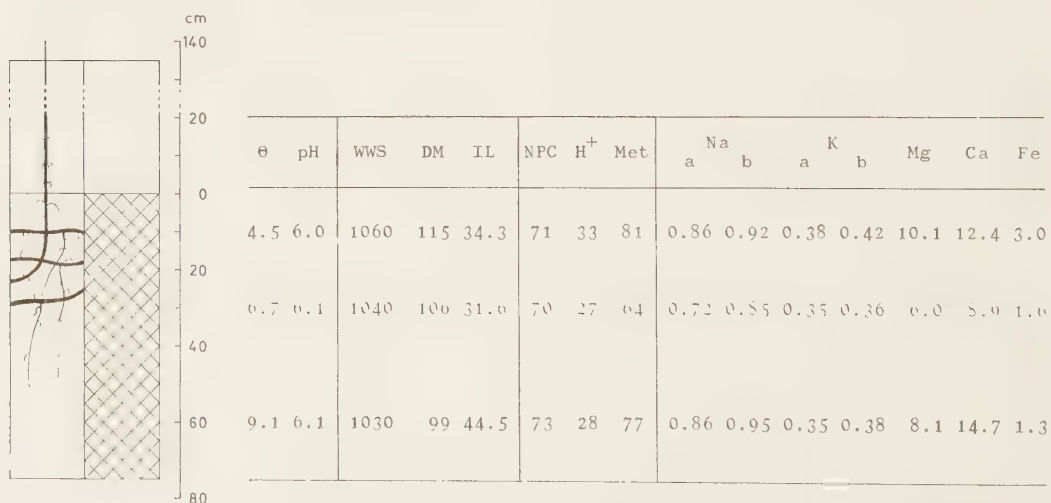


Fig. 71. Biotope 23 Orlunden 631212. Vertical section and soil analyses.

10 cm, but they were observed down to 20 cm. Thick roots occurred down to 65 cm. In the ferruginous soil there was a well developed fine root layer. Fine roots, though very few, were found at nearly all levels down to 65 cm.

In biotope 23 horizontal rhizomes occurred between 10 and 30 cm. Thick roots were observed down to 50 cm.

Shoot density. In both biotopes the density varied between 20 and 35 during the observation period.

Flowering time. The panicles first began to flower closest to the shore line and from there the flowering proceeded lakewards for one to two weeks. The data given here refer to biotope 22.

The last week in Sept. was noted as the earliest date for flowering. Usually, however, the panicles were not in full flower until the first week in Oct. In 1958 and 1962 the panicles did not flower at all.

Panicle frequency. Rather great variations between different years were recorded. On the average the frequency was 60—80 % in biotope 22 but only ca. 15 % in biotope 23.

Further data in Tables 28—34.

The Streams Western and Eastern Orlundsån

With Biotopes 24—25

General Description

The biotopes were situated within reaches where the streams flow through cultivated valleys with fine-grained minerogenic sediments. The courses have been straightened and deepened and now and then they were cleaned from macrophyte vegetation. During the observation period 1955—1964 the biotopes were untouched until 1962, when the

hyperhydate vegetation was treated with herbicides and the investigations on the stabilized *Phragmites* stands were spoiled.

Biotope 24

A. Environment

Situation (Fig. 60). Ca. 100 m north of the dairy at Grånum.

Physiographic survey. The direction of the stream is north-south. The breadth is 2—3 m and the banks about 2.5 m high.

The *Phragmites* stand was nearly pure. Other macrophyte species noted within this stream reach were *Alisma plantago-aquatica*, *Bidens tripartita*, *Carex elata*, *C. vesicaria*, *Lysimachia thyrsiflora*, *L. vulgaris*, *Myosotis palustris*, and *Typha latifolia*. Here and there the stream was choked by *Callitriche* and *Nitella*.

The water (Table 26). During the vegetation period the depth normally varied from 40 to 75 cm. In exceptionally dry summers (e.g. 1959) the depth decreased to 20 cm. The current velocity was slight to very slight. Water quality data (samplings in the unpolluted stream in Aug., Sept., Oct., Nov., 1955, May, Sept., Oct. 1956): Col 5—25, m=15, KMnO₄-cons. 23—56, m=43 mg/l, Sp. cond. 87—120, m=100 µS, pH 6.5—6.9, m=6.7, Cl 340—440, m=380 µmol/l, and (O₂)s 85—118, m=98 %.

In later years a central potato starch factory was built upstream from the biotope and waste water led off in pipe lines and sprayed on the fields beside the stream. During the working season a rich development of water moulds was to be found in the stream. Cf. water analyses in Table 26; in Dec. 1963 the stream was polluted, in Aug. 1964 it was unpolluted.

The bottom (Table 25). From 0—20 cm the soil was grey and from 20—

Table 25. Soil analyses from biotopes 24 Grånum and 25 Håkantorp 631212. The sampling levels for biotope 25 refer to the surface of the minerogenic bottom.

Bio- tope	Level cm	WWS	DM	IL	NPC	H ⁺	Met	Na		K		Mg	Ca	Fe
								a	b	a	b			
24	10	1820	1370	1.5	55	39	48	0.77	0.93	1.32	1.31	3.5	5.6	15.8
	35	1660	1070	4.9	65	51	94	1.79	1.99	2.36	2.80	10.5	18.1	14.7
25	+3	1630	1020	5.0	80	32	125	0.82	0.89	2.37	2.05	12.1	13.2	20.3
	-12	1900	1520	0.5	90	7	60	0.97	1.29	10.1	10.1	8.1	16.6	18.6
	-44	1900	1540	0.3	90	6	57	0.87	0.97	13.2	9.61	6.3	16.6	22.8

45 cm dark grey, humic sand. Further down the sand was silty and clayey. At 27—29 cm there was a distinct layer of sandy gravel filled with badly smelling waste water. Unfortunately analytical data are available only after the waste water infiltration into the surrounding fields was started.

B. *Phragmites communis*

Rhizomes and roots. The horizontal rhizomes were concentrated between 25 and 40 cm. The highest frequency of fine roots was noted from the uppermost 6 cm. As a rule 2—3 basal shoot nodes had roots.

Shoot density. Ca. 65.

Flowering time. First to second week in Sept.

Panicle frequency. Ca. 65 %.

Further data in Tables 28—32.

Biotope 25

A. Environment

Situation (Fig. 60). Downstream from the bridge at Håkantorp.

Physiographic survey. The topographic conditions resembled those in biotope 24. About 100 m upstream from biotope 25 there was during the autumn and winter until 1959 an outlet of waste water from a potato starch factory. The stream was heavily polluted during the working

season, but during the rest of the year it was unpolluted.

The *Phragmites* stand was quite pure. Within this stream reach the following macrophytes were noted: *Alisma plantago-aquatica*, *Bidens tripartita*, *Carex elata*, *C. vesicaria*, *Eleocharis palustris*, *Glyceria fluitans*, *Lycopus europeus*, *Lysimachia vulgaris*, *Myosotis palustris*, *Phalaris arundinacea*, *Scirpus silvaticus*, *Solanum dulcamara*, *Spartanium erectum*, and *Typha latifolia*. Upstream from the waste water outlet the stream was occasionally choked by *Callitriche* and especially by *Myriophyllum alterniflorum*. During the working season a very rich water-mould growth was developed (above all by *Leptomitius lacteus*).

The water (Table 26). Water depth variations from 0 to 60 cm were noted in the vegetation periods. The current velocity was slight to very slight.

Water samples were taken in 1955—1956 on the same occasions as in biotope 24 (p. 109). Four samples were taken when the stream was unpolluted and three in the polluted stream. Water quality data (4/3 samples): Col 20—80/20—40, m=40/30, KMnO₄-cons. 44—95/140—370, m=68/270 mg/l, Sp.cond. 82—100/110—160, m=89/140 μ S, pH 6.7—6.9/6.2—6.4, m=6.8/6.3, Cl 340—390/390—450, m=350/420 μ mol/l, and (O₂)s 85—105/59—91, m=94/71 %.

The bottom (Table 25). In the unpolluted biotope a sandy detritus layer, 30—40 cm thick, was collected between

the *Phragmites* shoots. The underlying minerogenic soil was light grey silt, with layers of blue-grey clay. Boulders at 55 cm.

The percentage of neutralization was lowest in the uppermost layer, which, however, showed the highest figure for total amount of extractable cations. On an equivalent basis the sum of the analysed elements in the minerogenic soil considerably exceeded the amount calculated from the pH changes in the HAc-extracts. The same conditions were found in other similar soils. The content of K in the clayey silt was noticeably high.

B. *Phragmites communis*

Rhizomes and roots. The greatest concentration of horizontal rhizomes occurred from the lowermost layer of the detritus bank down to 25 cm in the minerogenic bottom. Thick roots were found down to the boulders. Fine roots were richly developed in the detritus bank and 1 to 3 of the basal shoot nodes usually had fine roots.

Shoot density. Until 1960 the shoot density was about 100. In 1961 it decreased to ca. 40.

Flowering time. Second to third week in Sept.

Panicle frequency. Until 1960 ca. 90 %, in 1961 ca. 70 %.

Further data in Tables 28–32.

Norjesund

With Biotopes 26, 26 A, 27, 27 A—C, 28, 29,
and 29 A

General Description

Norjesund (56°7'N, 14°41'E) is the outlet for Western Örlundsån and for water pumped from Vesan (cf. p. 96). During the nine-

teenth century and the first quarter of the twentieth century Vesan was overgrown to a large extent by *Phragmites* (Fig. 72) and this area has since long been generally known as having very large reed-beds (SJÖBORG 1792).

According to the local inhabitants *Phragmites* occurred in the upper half of Norjesund also before the walling-in and drainage of Vesan. In the lower part the hyperhydric vegetation was, however, very sparse. Along the banks the bottom consisted of sand and the river mouth was used as a bathing place.

In connection with the drainage of Vesan, canals were cut through the *Phragmites* stands and plaur-like rhizome aggregates were transported to Norjesund with the water, which during the canalization period contained large amounts of suspended gyttja. Along the banks in the lower part of Norjesund *Phragmites* stands were developed from rhizomes originating from different parts of Vesan. Simultaneously with the rapid growth of these stands a sedimentation took place within them. Continuous reed-beds of *Phragmites*, only in a few reaches interrupted by other macrophytes, were developed from the 1920's along the banks of the lower part of Norjesund. In the successively narrowing channel between the reed-beds the bottom, due to the current conditions, still is minerogenic. However, the channel has steep sides of clay gyttja, accumulated and held together by *Phragmites* shoots, rhizomes and roots (Fig. 73).

In Norjesund there has also been a precipitation and sedimentation of organic matter discharged with the waste water from potato starch factories. During the working season the water in Norjesund sometimes had a pea soup-like appearance.

The monthly mean variation of the sea level at the coast of Blekinge amounts only to ca. 18 cm (6 readings per day at Kungsholmen), but the mean difference between the yearly lowest and highest level during the period 1955–1964 was 127 cm (Fig. 111). The difference between the recorded (one reading per day) lowest and highest water level in the lower part of Norjesund during the periods May 29–Dec. 4, 1963 and April 1–Oct. 12, 1964 was 86 cm (Fig. 74). The

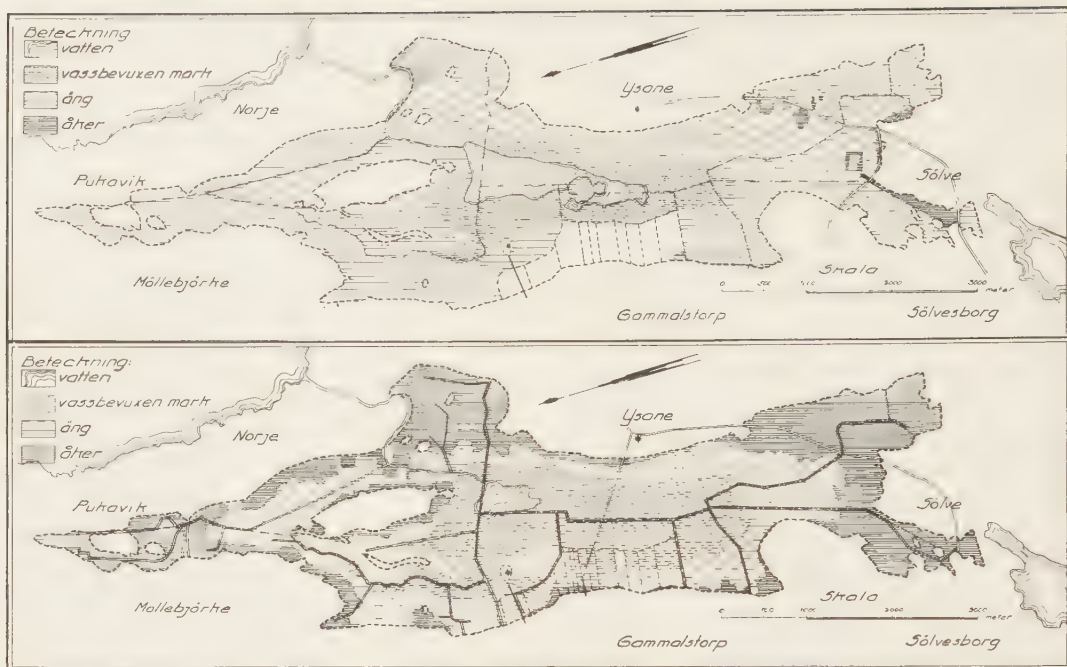


Fig. 72. The distribution of reed-beds etc. in Vesna 1805—1826 (top) and 1925. Norjesund is the outlet from Vesna to the Baltic (top left in the maps). The system of canals dug in connection with the drainage of Vesna indicated in the lower map. Key to the signs: vatten=water; vassbevuxen mark=reed-beds (*Phragmites*); äng=meadow; åker=arable land. (From LARSSON 1934.)

lowest water levels occur in March to May and the highest in August and September.

In that lower part of Norjesund within which the biotopes 26—29 were situated (Fig. 85), there is an alternation between fresh water and mixohaline water during different parts of the year. Broadly speaking, freshwater conditions are prevalent during the spring (largest supply of fresh water in connection with low sea water level), sudden short-time alternations between fresh and mixohaline water are most frequent in early summer, while there is often mixohaline water in Norjesund during the late summer and autumn (high sea water level). From this general scheme, however, there are many exceptions, which besides irregular changes in sea level and in the supply of water by Western Örlundsån are due also to the amount of water which is pumped when needed from Vesna to Norjesund.

In Norjesund the transparency was lowest during the autumn when the water was heavily polluted. The oxygen saturation was then low at all three sampling stations included in Table 27 and the specific conductivity high in Western Örlundsån. The conductivity as well as the chloride content was always relatively high in the Vesna canal which contains partly drainage water from mixohaline gyttja soils. The — with respect to the season — fairly irregular alternation between fresh and mixohaline water in Norjesund is evident from the conductivity and chloride values. Now and then the water in Norjesund was turbid from clay. The sediments deposited here are in the main clay gyttja.

The direction of the river mouth Norjesund is southwest-northeast. South of the lower Norjesund are cultivated fields and to the north of the western part of this reach

pine forest grows on the sandy soil. The biotopes were exposed to easterly winds (from the Baltic). The current velocity in Norjesund was slight and the wave action weak.

In the hyperhydate vegetation in the lower part of Norjesund *Phragmites communis* was the totally dominating species. The composition of the vegetation is outlined in the maps in Figs. 75 and 85.

In the upper part of Norjesund there were large stands of *Sagittaria sagittifolia*.

In the lower part there was, with the exception of occasionally occurring *Lemna minor*, practically no ephydate vegetation and the hyphydates were represented mainly by single individuals of *Potamogeton perfoliatus*. In the upper part the surface was in some reaches nearly totally covered by the leaves of *Nuphar luteum*, *Nymphaea alba* and *Potamogeton natans*.

Until the beginning of the 1960's the vegetation was allowed to develop without any appreciable attempts being made to diminish or regulate it from a quantitative point of view. However, from then on mechanical cleanings were carried out here and there, and in the spring of 1964 a fairly large part of the *Phragmites* stands in the lower Norjesund was destroyed and the environmental conditions in the littoral zones changed.

Biotope 26

Biotope for Hexaploid *Phragmites communis*
Type A in Norjesund

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 76). In the middle and outer zone the *Phragmites* stand was pure with the exception of single individuals of *Alisma plantago-aquatica* and *Carex pseudocyperus*. The dry *Phragmites* stems remained unbroken for at least one vegetation period.

The water (Table 26). In surface water samples taken during the vegetation period in 1963 the specific conductivity varied from ca. 0.4 to ca. 1.0 mS.

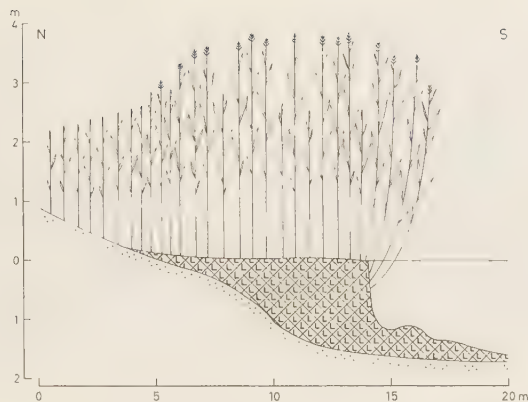


Fig. 73. Stratigraphic section through biotope 27 C Norjesund. Compare Figs. 75 and 85.

The change in the conductivity of the interstitial water (sampled in dug pits) from the surface soil layer showed that course which is characteristic of Norjesund as a whole, viz., fairly low conductivity in the spring and then an increase during the vegetation period.

The ionic composition of the water was dependent on the proportions of waters from the three different sources, Western Örlundsån, the Vesan canal, and the Baltic.

The bottom (Fig. 77). The surface was either bare clay gyttja or it was

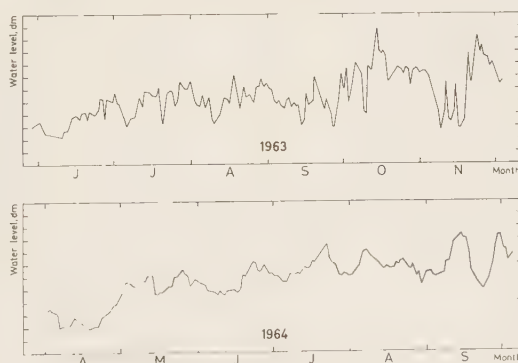


Fig. 74. Water level fluctuations in Norjesund.

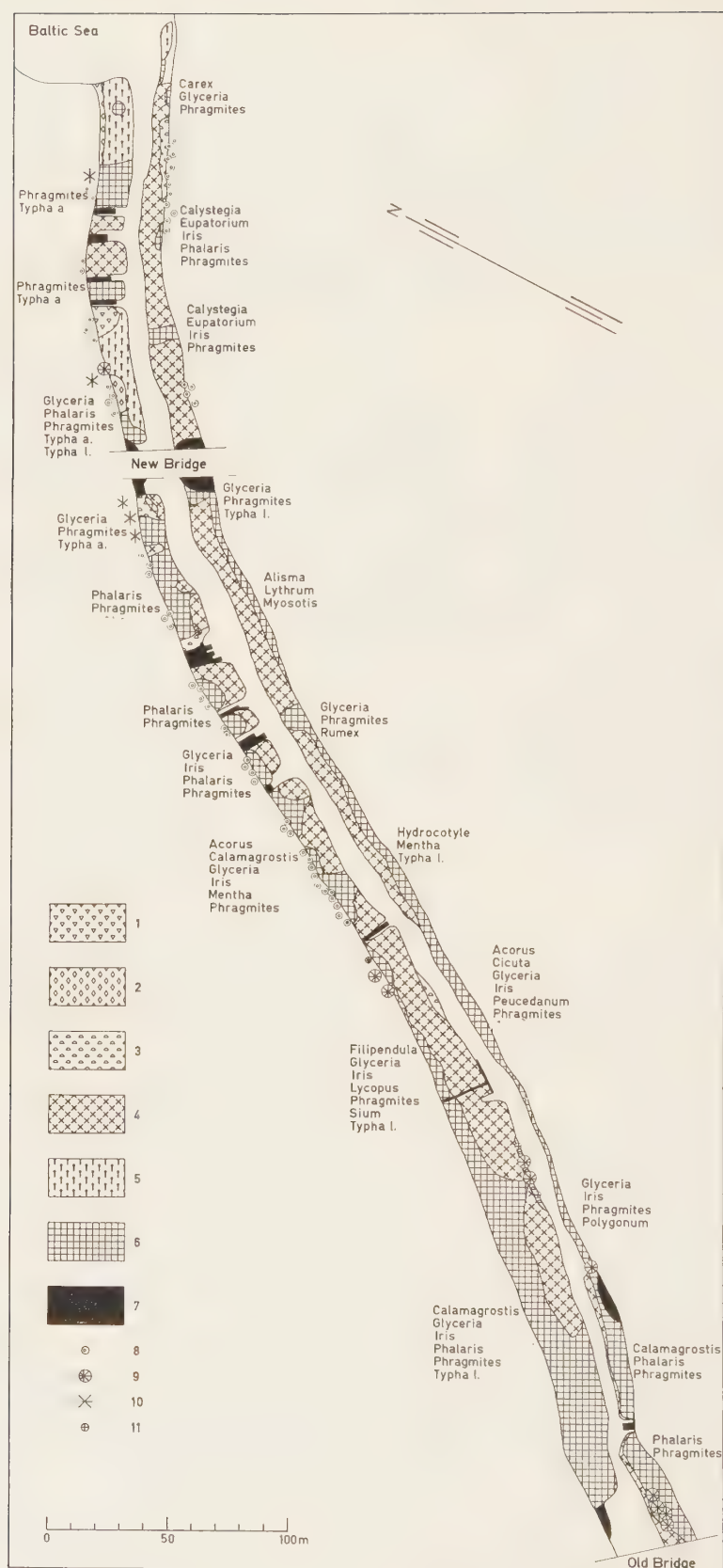


Fig. 75. The macrophyte vegetation in Norjesund 1962. 1. *Acorus calamus*. 2. *Glyceria maxima*. 3. *Phalaris arundinacea*. 4. *Phragmites communis*. 5. *Typha angustifolia*. 6. Mixed stands, the most prominent constituents indicated. 7. Filling and small bridges. 8. *Alnus*. 9. *Betula*. 10. *Pinus*. 11. *Salix*.

List of plant species indicated in the mixed stands: *Acorus calamus*, *Alisma plantago-aquatica*, *Calamagrostis canescens*, *Calystegia sepium*, *Carex riparia*, *Cicuta virosa*, *Eupatorium cannabinum*, *Filipendula ulmaria*, *Glyceria maxima*, *Hydrocotyle vulgaris*, *Iris pseudacorus*, *Lythrum salicaria*, *Myosotis palustris*, *Peucedanum palustre*, *Phalaris arundinacea*, *Phragmites communis*, *Polygonum amphibium*, *Rumex hydrolapathum*, *Sium latifolium*, *Typha angustifolia* and *T. latifolia*.

Fig. 76. Norjesund. To the right biotope 26 and to the left biotope 26 A. — Photo S. Björk 580912.



covered by a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

- 0— 13 cm Brown clay gyttja with a somewhat granular structure.
- 13— 88 cm Clay gyttja. The soil was marbled, as black portions were interspersed in the dark olive-green brown gyttja. In the lower part black green and of buttery consistency. Large black portions were found (Aug. 1963) at 25, 42, 57, and 80 cm.
- 88— 92 cm Grey sand.
- 92— 99 cm Grey black soil of clay gyttja appearance.
- 99—130 cm Dark grey clay gyttja with grey sand layers at 100 and 103 cm.

At the end of May 1963 the superficial layer of brown clay gyttja was 8 cm thick. At the end of June it was 13 cm, and the same thickness was recorded at the beginning of August.

At the 60 cm level, i.e., in the marbled clay gyttja, E_h values of ca. -160 mV were obtained in the black portions, while values of ca. -110 were recorded in olive-green brown clay gyttja close to *Phragmites* rhizomes.

The proportions of organogenic and minerogenic matter were about the same down to 85 cm. The amounts of extract-

able metallic cations were high and of the same order (216—238 meq/l whole soil) to the mentioned depth, but, on the other hand, fairly great variations in the percentage of neutralization were recorded.

The amounts of extractable Na and also K decreased downwards, there was a trend for Fe to increase in the same direction, while Mg and Ca were about the same at all levels.

The temperature figures from May 29, 1963 (Fig. 77, the text) give the conditions prevailing at the two-leaf stage of the *Phragmites* shoots, which then had a length of 70 cm. On Aug. 2, 1963, when the temperature figures given in the table in Fig. 77 were obtained, the length of the shoots was 315 cm, but the panicles were not yet visible.

B. *Phragmites communis*

Rhizomes and roots (Fig. 77). Horizontal rhizomes occurred from 15 to 80 cm (dead rhizomes to 90 cm). The highest frequency was recorded between 30 and 60 cm. Fine roots, emanating from thick ones, were found down to 85 cm. Probably roots occurred also somewhat below this level. The fre-

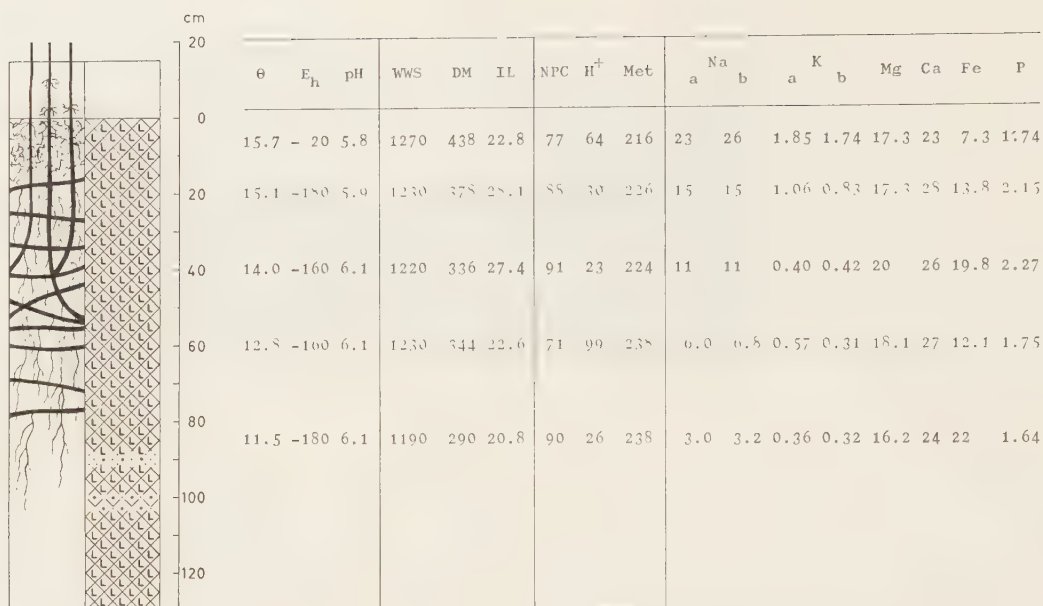


Fig. 77. Biotope 26 Norjesund 630802. Vertical section and soil analyses. Soil temperature 630529 at the same levels as in the table: 12.9, 10.7, 8.9, 7.5, 6.2°C.

quency of fine roots was very high in the superficial layer down to 20 cm.

Shoot density. According to records in 1959 to 1963 the shoot density varied between 45 and 65.

Flowering time. The panicles were usually not fully grown out until the first or second week in Sept. and the flowering time varied from the last week in Sept. to the first week in Oct. In some years many panicles were not developed and did not flower at all. (If the summer and autumn were especially warm the panicle development and flowering occurred somewhat earlier than stated above. In 1966 the panicle development was unusually good. The flowering then began in the third week in Sept.)

Panicle frequency. From 10 to 35 % in different years.

Further data in Tables 28—31, 33—34.

Biotope 26 A

A. Environment

Situation. See Fig. 85.

Physiographic notes (Figs. 76 and 78). Extending from the northern bank there was a broad *Phragmites* reed-bed within which the land formation had advanced farther than in any of the other biotopes mentioned from Norjesund. The biotope was located in the outer zone of the reed-bed.

In the biotope no other macrophytes were intermingled. In some years part of the dry stems remained for the next vegetation period.

The water (Table 26) and the bottom. The changes in the water quality were about the same as in the adjacent biotopes 26 and 27C and the bottom conditions resemble those described for biotope 26.

B. *Phragmites communis*

Rhizomes and roots. See biotope 26.

Shoot density. Ca. 60.

Flowering time. See biotope 26.

Fig. 78. Norjesund. In the foreground the margin of the stand with biotope 26 A. Note that the *Phragmites* leaves have bent-down edges. In the background biotope 27 B in the stand with large panicles. — Photo S. Björk 600902.



Panicle frequency. Ca. 40 %.
Further data in Tables 28—32, 34.

Biotope 27

Biotope for Hexaploid *Phragmites communis*
Type B in Norjesund

A. Environment

Situation. (See Fig. 85).

Physiographic notes (Fig. 79).
The new bridge has divided the originally

continuous stand into two parts. Besides *Phragmites* only a few single individuals of *Alisma plantago-aquatica* and *Glyceria maxima* occurred. Fairly often the dry *Phragmites* stems remained erect for the next vegetation period.

The water (Table 26). In seven samples taken in 1963 the specific conductivity of the surface and interstitial (from dug pits) water did not exceed 1.6 mS. However, in the middle zone of the channel outside the biotope the con-



Fig. 79. Norjesund. View to the west from the new bridge. Biotope 27 to the left. — Photo S. Björk 620821.

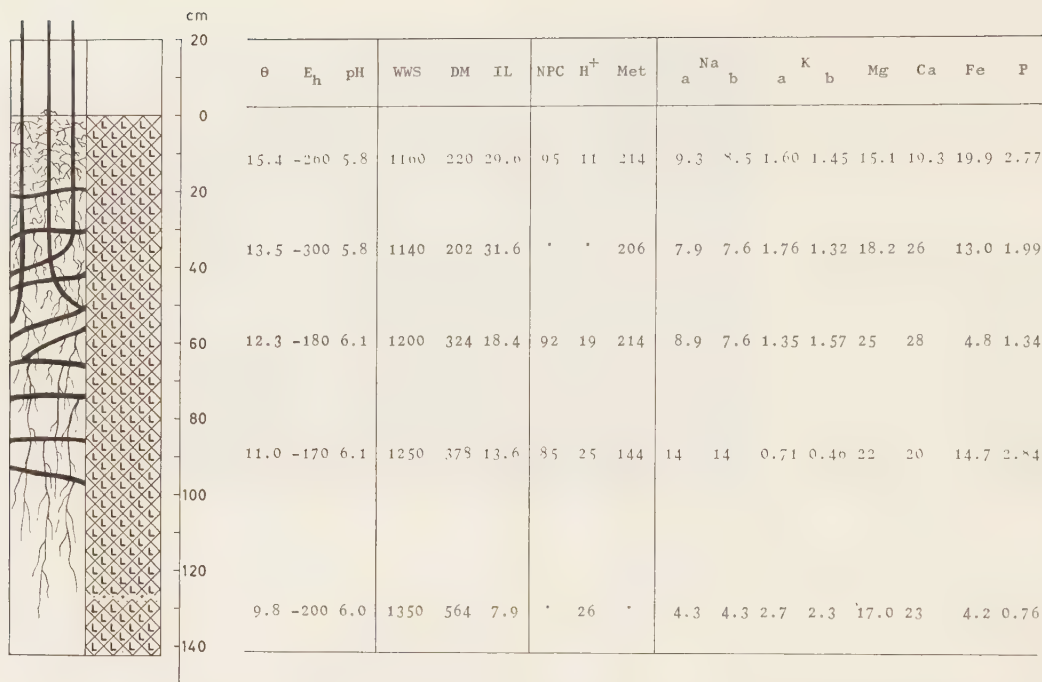


Fig. 80. Biotope 27 Norjesund 630801. Vertical section and soil analyses. Soil temperature 630529 at the same levels as in the table: 12.8, 8.9, 7.1, 6.2, 6.1°C.

ductivity sometimes rose to 9 mS. The conductivity of the interstitial water in the superficial soil layer became higher during the vegetation period in 1963. The concentrations of the different analysed elements varied with the proportions of water of different origin.

The bottom (Fig. 80). The surface was bare gyttja or covered by a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

0—55 cm Black clay gyttja.

55—144 cm In the upper part grey-brown green clay gyttja, here and there marbled (black portions). Downwards the clay gyttja became somewhat sandy and olive-green grey to olive-green brown in colour. At 127 cm a sand layer with wood pieces.

The soil analyses in Fig. 80 refer to samples taken on Aug. 1, 1963. On that

occasion the biotope was submerged by 20 cm water and the colour of the upper layers of the clay gyttja was black right up to the surface, which, however, had a brown colour. In May of the same year the upper 10 cm of the clay gyttja were brown, only here and there with some black portions. In Aug. the lowest E_h values were obtained in the black clay gyttja, while the underlying greenish gyttja had a markedly higher redox potential.

Down to 60 cm the amount of extractable metallic cations was ca. 210 meq/l at all sampled levels and the percentage of neutralization was high but downwardly decreasing. There was no clear gradient in the concentration variations of the analysed elements.

The soil temperature figures (Fig. 80, text and table) denote the conditions at

Fig. 81. Norjesund. In the foreground the stand with biotope 27 B. In the background biotope 29 A in the stand with high density and small panicles. — Photo S. Björk 600902.



the *Phragmites* two-leaf stage (May 29) and at the stage when the panicles were grown out to 90—100 % (Aug. 1) in 1963.

B. *Phragmites communis*

Rhizomes and roots (Fig. 80). The highest frequency of horizontal rhizomes was found between 30 and 65 cm, but rhizomes were noted from 15 to 95 cm. Thick roots occurred down to 120 cm and fine roots were found at 127 cm. The highest frequency of fine roots was in the superficial 40 cm.

Shoot density. In the years 1959—1963 the recorded shoot densities varied between 55 and 70.

Flowering time. The characteristically large panicles were usually completely grown out already in the middle of Aug., in some years even as early as ca. July 25. The flowering time, which was fairly short, as a rule occurred during the period from the last week in Aug. to the second week in Sept. It was typical of this type of *Phragmites* that the hairs from the rhachilla were already grown out in the new flowering

panicle, giving to this very early a silvery appearance.

Panicle frequency. 50—60 %.

Further data in Tables 28—30, 33—34.

Biotope 27 A

A. Environment

Situation. See Fig. 85.

Physiographic notes In the main the environmental conditions here were the same as those described for biotope 27. The fairly open *Phragmites* stand was only slightly intermingled with other macrophytes. Some few individuals of *Alisma plantago-aquatica* and *Glyceria maxima* grew in the black H₂S-smelling clay gyttja.

B. *Phragmites communis*

Vertical distribution of rhizomes and roots and flowering time as in biotope 27.

Shoot density. Ca. 35.

Further data in Tables 28—29, 31—32.

Biotope 27 B

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 81).



Fig. 82. Norjesund. View to the east from the new bridge. Biotope 28 situated to the right, half-way to the mouth in the Baltic, and biotope 29 to the left, somewhat further seawards. Note the sharp limit (marked with a line) between the hexaploid type B stand with large panicles (in the foreground) and the tetraploid type A stand (with biotope 28), still with undeveloped panicles. — Photo S. Björk 620818.

Broadly speaking, the course of the intermingling of the *Phragmites* stand with other macrophytes in connection with the overgrowth and land formation of this reach was the same as that described for biotope 27C.

With respect to water depth and quality as well as to bottom, the environmental conditions correspond also very closely to those described for biotope 27C.

B. *Phragmites communis*

Vertical distribution of rhizomes and roots and flowering time as in biotope 27C.

Shoot density. According to determinations 1958—1961 the density varied from 40 to 80.

Panicle frequency. Ca. 50 %.

Further data in Tables 28—32, 34.

Biotope 27 C

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 73). At the beginning of the observation period 1955—1963 this stand was nearly pure. It

became, however, gradually more intermingled, first with *Glyceria maxima* and then with *Carex acuta*. These changes have taken place in connection with the land formation in the whole reach within which the biotope was situated. A retreat of *Phragmites* has been noted in the landward zone of the stand since 1955. The samplings for biometric analyses of *Phragmites* were always taken in the outer zone.

The water. See Table 26.

The bottom. In the half of the stand towards the water the bottom consisted of black clay gyttja to a depth of 55—75 cm (when emerged the superficial layer became brown) and beneath this brown to brown-black clay gyttja. A stratigraphic section through the biotope is shown in Fig. 73.

B. *Phragmites communis*

Rhizomes and roots. No discrepancies from the conditions in biotope 27 were noticed.

Flowering time. Some days later than in biotope 27.

Shoot density. During the years 1958—1963 the registered shoot densities varied from 40 to 60.

Panicle frequency. 60—70 %.

Further data in Tables 28—34.

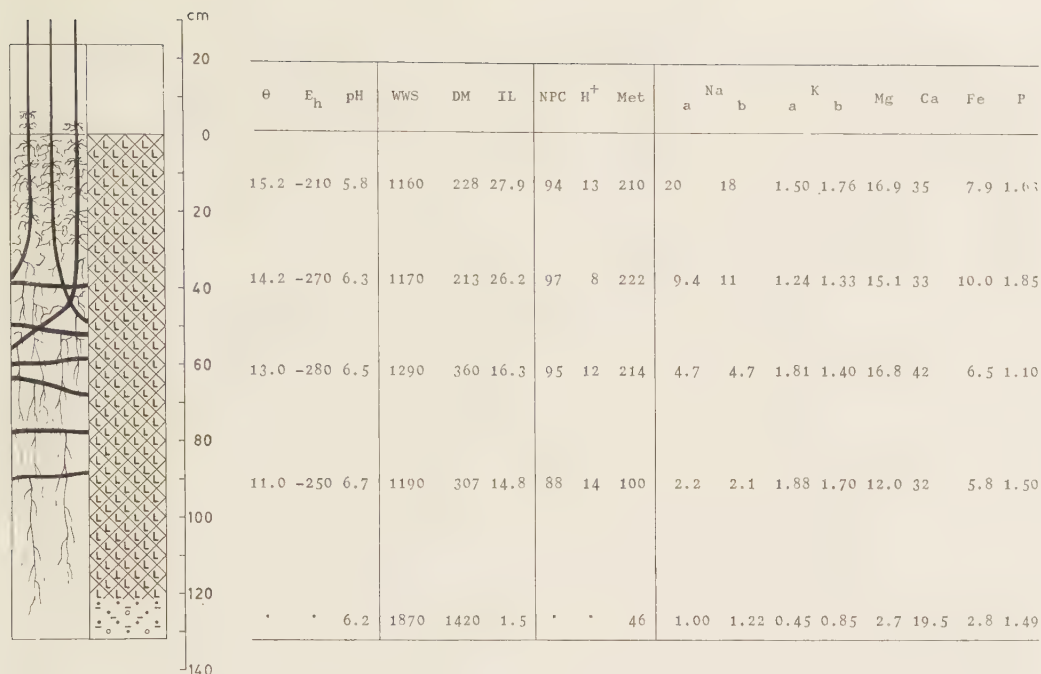


Fig. 83. Biotope 28 Norjesund 630730. Vertical section and soil analyses. Soil temperature 630529 at the same four upper levels as in the table: 13.1, 9.6, 7.7, 6.6°C.

Biotope 28

Biotope for Tetraploid *Phragmites communis*
Type A in Norjesund

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 82). All samplings were made in the middle zone of the *Phragmites* stand, where there was no intermingling of other macrophytes. In some years the dry stems remained for the next vegetation period, in others they were broken in the spring.

The water (Table 26). The analyses give a clear picture of the great and rapid changes in the water quality in Norjesund. In spite of the fact that the distance to biotope 29 was only about 25 m, there were, at the same time, often rather great differences (primarily caused by irregularities in the current

conditions) in the water quality between the two biotopes.

The bottom (Fig. 83). The surface was covered by a 2 cm thick layer of coarse *Phragmites* detritus.

Stratigraphy:

0—79 cm Marbled (brown and black portions) loose clay gyttja.

79—122 cm Olive-green brown clay gyttja.

122—132 cm Grey gravelly sand with thin layers of organic matter.

When *Phragmites* was at the two-leaf stage at the end of May 1963 the temperature in the surface layer was 16—17°C (bottom emerged). In the lower layers penetrated by roots, the temperature was, however, only 6.5°C. On July 30, when the *Phragmites* panicles were grown out to about 30 %, the temperatures at the corresponding levels were 15.5 (bottom submerged and

overshadowed by the *Phragmites* shoots) and ca. 10°C.

The percentage of neutralization as well as the amounts of extractable metallic cations were about the same down to 60 cm, but at 90 cm the percentage of neutralization became lower. The Na content decreased downwards, without doubt a consequence of the fact that the supply of fresh water by Western Örlundsån is less nowadays than earlier. As for extractable K, Mg, Ca, and Fe the sand showed the lowest figures. At the next lowest sampled level (ca. 90 cm) the K content was fairly high. With respect to the concentration of the other elements this level formed a transition to the overlying, fairly uniform gyttja.

B. *Phragmites communis*

Rhizomes and roots (Fig. 83). Horizontal rhizomes occurred down to 90 cm. The highest frequency was noted from 50 to 60 cm. Fine roots were found in the sandy layer at 127 cm.

Shoot density. In 1958—1963 variations from 60 to 90 (mean 75) were recorded.

Flowering time. On July 30, 1963 the panicles were grown out to 30 %, but on Aug. 14, 1962 only the uppermost tips of the panicles were visible. In the middle zone of the stand the flowering time usually occurred from the first to the third week in Sept. The flowering of *Phragmites* growing on the sandy banks landwards from the biotope began about 10 days earlier than that of the water-growing *Phragmites*.

Panicle frequency. Variations from 50 to 75 % were registered during the observation period.

Further data in Tables 28—34.

Biotope 29

Biotope for Tetraploid *Phragmites communis*
Type B in Norjesund

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 82). In the inner part of the stand, where the samplings were made, no other macrophytes than *Phragmites communis* occurred. In some years the dry stems remained for the next vegetation period, in others they were broken in the spring.

The water (Table 26). The changes in water level and the supply of fresh and mixohaline water made the surface water quality very variable. As in Norjesund as a whole, the changes sometimes occurred very suddenly (cf. the data for July 30 and Aug. 1, 1963), often as rapid as in one hour.

In 1963 the specific conductivity of the interstitial water was, after the spring washing with fresh water as low as 0.33 mS in May. Due to the periodical overflows with mixohaline water during the summer, the conductivity gradually increased towards the autumn, viz., to 1.2 mS in June and to 1.8 mS in Sept. (all samples from dug pits).

The bottom (Fig. 84). The surface was mostly bare clay gyttja.

Stratigraphy:

- 0—23 cm Brown clay gyttja.
- 23—33 cm Marbled brown and black transition layer of clay gyttja.
- 33—87 cm Black clay gyttja.
- 87—91 cm Grey sand with gyttja.
- 91—96 cm Black clay gyttja.
- 96—98 cm Grey sand with gyttja.
- 98—105 cm Grey sandy gravel.
- 105—108 cm Dark grey sand.

After being emerged for some time the upper layer of the black and H₂S-smelling clay gyttja, the characteristic sedi-

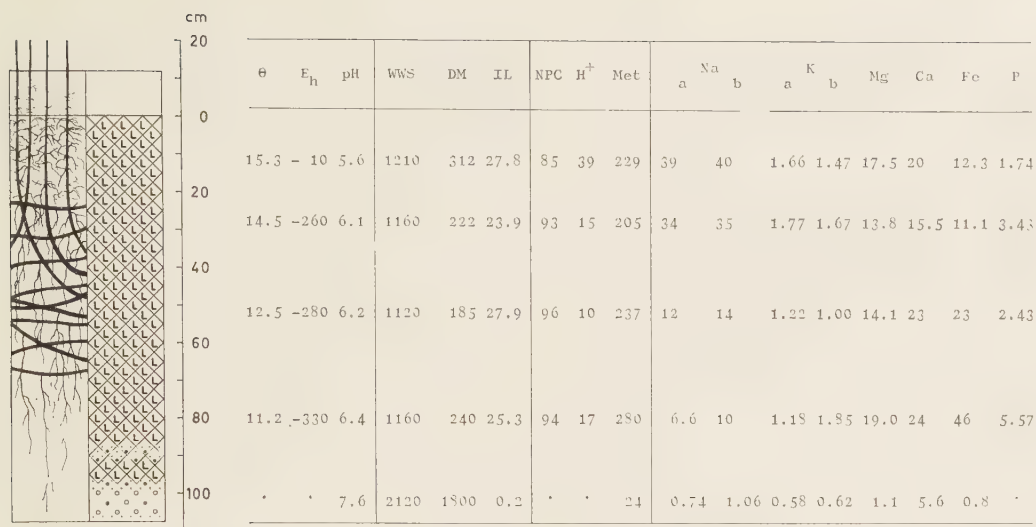


Fig. 84. Biotope 29 Norjesund 630730. Vertical section and soil analyses. Soil temperature 630529 at the same four upper levels as in the table: 14.7, 13.2, 10.8, 8.8°C.

ment of Norjesund, became brown (compare the figures for E_h) and a brown and black marbled layer constituted the transition to the underlying black clay gyttja.

Two series of measurements illustrating the temperature conditions on May 29 and July 30, 1963 are given in Fig. 84 (text and table). In May the temperature of the surface layer of the emerged bottom was high. At a level of ca. 85 cm the temperature was, however, only 8.5°C. At this time *Phragmites* was at the two-leaf stage. On July 30, when the panicles were grown out to 90—100 %, the temperature at the mentioned level had risen to 11°C. As the biotope was submerged (water depth 12 cm) on that occasion, the temperature of the surface layer was, however, lower than on May 29, when the bottom was emerged and not shadowed by *Phragmites* shoots.

The brown (more oxidized) clay gyttja had a lower pH and a lower percentage of neutralization than the black one. The

amount of extractable metallic cations varied from 205 to 280 meq/l in the clay gyttja and decreased to 24 in the underlying sandy gravel, which was furnished with fresh subsoil water. The amount of extractable Na decreased markedly downwards. To some extent this was also the case for K, while Mg and Ca (with the exception for the minerogenic soil) were fairly constant throughout. In the lower layers of the clay gyttja the amount of extractable iron was remarkably high.

B. *Phragmites communis*

Rhizomes and roots (Fig. 84). Horizontal rhizomes occurred between 25 and 70 cm. The highest frequency was noted from ca. 50 cm. Thick roots were observed down to 100 cm, i.e., down into the sandy and gravelly layers. The highest frequency of fine roots was recorded down to 20 cm. One to four of the lowermost nodes of many shoots had fine roots.

Shoot density. In the years 1959—1963 densities from 100 to 130 were registered.

Flowering time. In the middle zone of the stand the flowering occurred from the last week in Aug. to the second week in Sept. As always in littoral *Phragmites* stands the flowering began in the landward part and from there it successively spread to parts growing in deeper water.

Panicle frequency. 40—50 %.

Further data in Tables 28—34.

Biotope 29 A

A. Environment

Situation. See Fig. 85.

Physiographic notes (Fig. 81). In intact status the dense *Phragmites* stand was without intermingling with other macrophytes. The dry stems usually remained for at least one vegetation period. Stands of the same *Phragmites* type occurred at the northern shore of the lower part of Norjesund within two reaches west of the new bridge (see Fig. 85). Unfortunately both were nearly totally spoiled in connection with the construction of a landing-stage and a sewage treatment plant. Therefore the observation material from this biotope is fairly sparse.

As for water quality and bottom conditions see the adjacent biotopes 27, 27A—C.

B. *Phragmites communis*

Flowering time. A few days later than in biotope 29.

Further data in Tables 28—29, 32, 34.

Survey of the Analyses

The region is included as an example of the ecologic conditions concerning *Phragmites communis* prevailing in the small watercourse systems of South Sweden. The upper parts of these systems drain areas belonging to the South Swedish Upland or the slopes thereof, i.e., more or less oligotrophic regions. On the whole, the conditions there contrast very strongly to those which are characteristic of the mouth parts of the streams, where there are often sediments of clay gyttja and at times an influx of mixohaline water. *Phragmites communis* occurs in practically all lakes, in many reaches of the streams and is very frequent in the mouth areas. The possibilities for exemplifying the variation within the species are very good.

Lake Vitavatten with biotope 18 was before 1959 only slightly affected by

man. In Lake Orlunden with biotopes 22—23 the water level was lowered so that the sediments here and there (as in biotope 23) were accessible for *Phragmites*. The shallow Lake Vångasjön with biotopes 19—21 is in a stage of complete overgrowing after water level lowering. The conditions in the streams draining the lakes are exemplified by biotopes 24 Gränum in Western Orlundsån and 25 Håkantorps in Eastern Orlundsån and by biotopes 26—29 Norjesund the conditions in the mouth of W. Orlundsån in the Baltic are illustrated.

In this survey the environmental conditions in the northern biotopes (18—25) are compared with those in Norjesund (26—29). In summarizing the analyses on *Phragmites* the clones are not — as concerning the two preceding regions — grouped with respect to the environ-

mental conditions in the biotopes but tetraploid and hexaploid clones are mostly treated apart and mutually compared. In the Synthetic Part an attempt has been made by means of observations from, among other things, this region to show the genotypically induced variation and the ability of modification in *Phragmites*.

A. Environment

In the light *Phragmites* stand in 18 Vitavatten only scattered shoots and individuals of *Carex rostrata*, *Equisetum fluviatile*, *Juncus bulbosus* and small-leaved *Nymphaea* were found. In 21 Vångasjön there was a mat of *Nitella* and scattered shoots of *Carex rostrata*, *Equisetum fluviatile*, and *Scirpus lacustris*. In 22 Orlunden the hyperhydrites mentioned occurred together with *Alisma plantago-aquatica*, *Carex vesicaria*, *Eleocharis palustris*, *Glyceria fluitans*, *Lobelia dortmanna*, *Lysimachia thyrsiflora*, *L. vulgaris*, and *Myosotis palustris*. A carpet of isoetids occurred in biotope 23 Orlunden. The dense *Phragmites* stands in 19—20 Vångasjön as well as in 24 Grånum and 25 Håkantorps were pure or almost pure. In the streams *Alisma plantago-aquatica* and *Typha latifolia* occurred in the reaches with the biotopes. Also the *Phragmites* stands in the Norjesund biotopes 26—29 were pure or almost pure. The distribution of quantitatively more prominent macrophyte species in Norjesund is outlined in Fig. 75.

The greatest water depth at summer normal water level was lower than 50 cm in 18 Vitavatten, 19—20 Vångasjön, and 22 Orlunden. In 21 Vångasjön it was ca. 55 and in 23 Orlunden 80 cm.

Among the lakes Orlunden (regulated) showed the greatest water level fluctuations (about 100 cm) during the vegetation period. In the streams (with biotopes 24—25) the depth at summer normal water level was about 50 cm, but there were rather great fluctuations. As a rule, the bottom was more or less occasionally emerged in Norjesund in spring and early summer, but during the vegetation period there was a gradual increase in the water depth although irregular short-time fluctuations in the water level occurred (Fig. 74).

Moderate variations in the quality of the surface water (analyses in Tables 26 and 27) in the lake biotopes occurred in connection with water level fluctuations. In the streams there were seasonally occurring pollutions and in Norjesund the water quality varied with the supply of fresh and mixohaline water.

The water colour did not exceed 55 mg Pt/l in any biotope except in 24 Håkantorps where the value 80 was occasionally obtained.

The lowest specific conductivity, viz., 53 μ S, was obtained in 18 Vitavatten. In 22—23 Orlunden it was ca. 80 and in 19—21 Vångasjön ca. 95 μ S. During the main part of the vegetation period the streams with biotopes 24—25 were unpolluted and the conductivity of the water was slightly higher than in Orlunden.

In Norjesund there were great irregularities and short-time changes in the conductivity. The extreme conductivity values obtained in the middle part of the investigated lower reach are 0.5 and 9.1 mS.

In most biotopes the pH value was between 6.0 and 7.0 during the vegetation period. Though rather great varia-

tions occurred in most biotopes, there was a trend of downwardly increasing values in the watercourse system.

Among the biotopes in the northern part of the region (18—25) the lowest concentrations of all analysed elements as well as the lowest alkalinity were found in 18 Vitavatten. The conditions in all the northern biotopes contrasted highly to those prevailing in Norjesund (see Table 26). The surface water in the Norjesund biotopes not only had on the whole greatly increased concentrations of Na, K, Mg, Ca, and Cl but the concentrations were very variable.

The quality of interstitial water is exemplified from 19—20 Vångasjön, 22—23 Orlunden and from the Norjesund biotopes (Table 26).

In the gyttja in 23 Orlunden the conductivity of the interstitial water was only about 20 % higher than in the surface water. Among the analysed elements Na, Mg, Fe, and also K showed higher concentrations in the interstitial water.

In the gyttja in 19—20 Vångasjön the highest conductivity of the interstitial water was nearly twice that of the surface water. In comparison with the surface water there was a marked rise in the concentrations of all analysed elements (especially of Mg, Fe, and P) except K.

While the conductivity in the gyttja did not show any considerable vertical differences within the *Phragmites* rhizosphere there was a downward increase in the minerogenic bottom in 22 Orlunden. In comparison with the surface water the conductivity was 40 % higher at 5 cm and 160 % higher at 30 cm. The concentrations not only of Mg and Fe but also of K were considerably

higher, but the concentration of Cl was lower in the interstitial water from the superficial soil layer.

In Norjesund the superficial clay gyttja layer varied in consistency from being a black and H₂S-smelling soil with tar-like appearance and with very low permeability to water, to (after emergence) a brown granular soil which was more permeable to water. During the spring the superficial soil layer is washed with fresh water. As a rule the influence of mixohaline water increases during the vegetation period and the interstitial water becomes more saline.

The bottom analyses are exemplified in Figs. 64, 66, 68, 70, 71, 77, 80, 83 and 84 and in Table 25. The conditions in biotope 24 Grännum originally probably resembled those in 25 Håkantorp. Due to waste water infiltration the conditions have, however, been changed in recent years and this biotope is therefore excluded in this survey.

The extractable amounts of metallic cations were from 26 to 44 meq/l in the sand in 22 Orlunden and about 60 in the silt in 25 Håkantorp.

The amounts extractable from all gyttja types in the northern biotopes (18—20 and 23) fell within the range 48—82 meq/l. In the Norjesund biotopes more than 200 meq/l were extracted from the clay gyttja in nearly all sampled levels within the *Phragmites* rhizosphere.

In the minerogenic soils the percentage of neutralization was between 72 and 86 in 22 Orlunden and 90 in 25 Håkantorp.

As for the gyttja there was an evident gradient implying downwardly increas-

ing percentage of neutralization. The lowest figures, 41—50 % (pH 5.3—5.5), were obtained in 18 Vitavatten, and the highest, mostly above 90 % (pH 5.6—6.7), in Norjesund.

The amount of extractable Na did not exceed 1.6 mmol/l in any of the northern biotopes. In Norjesund most sampled layers had concentrations several times higher. The highest figures were obtained in the superficial soil layers.

The lowest amounts of extractable K were found in 18 Vitavatten (0.04—0.10 mmol/l in AmAc-extract), and there was a concentration increase in gyttja in the direction 18 Vitavatten, 19—20 Vångasjön, 23 Orlunden. In the last-mentioned biotope the concentration was about the same as in the lower layers in 26 Norjesund, viz., ca. 0.4 mmol/l. The other clay gyttja layers in Norjesund had about equivalent amounts to those found in the lower layers in 22 Orlunden, viz. ca. 1.5 mmol/l. The highest figures for the region, about 10 mmol/l, were obtained from the silt in 25 Håkantorp.

The contrast between the northern biotopes and Norjesund concerning the total amounts of extractable metallic cations is reflected also in the values for extractable Mg and Ca. However, the Ca amounts obtained in 18 Vitavatten were, compared with the total amounts, proportionally higher.

The lowest Ca/Mg quotients, about 1, were obtained in Norjesund and in the superficial soil layer in Håkantorp. Quotients >2 were found in 18 Vitavatten (gyttja), 25 Håkantorp (silt), 28 Norjesund (clay gyttja and sand), and 29 Norjesund (sand). In other biotopes the quotient was between 1 and 2.

The greatest amounts of Fe were

extracted from the clay gyttja in Norjesund and the silt in 24 Håkantorp.

The available analyses of extractable P indicate striking differences between the northern lakes and Norjesund. Thus it was (expressed as means of all sampled layers) about 0.006 mmol/l in 18 Vitavatten, about 0.07 in 19—20 Vångasjön and about 2.2 in 26—29 Norjesund.

Though the conditions concerning the analysed physical and chemical soil properties in the different Norjesund biotopes differed in some respects, this area may be looked upon as a fairly homogeneous one and very different from the northern area. Some of the differences between the Norjesund biotopes which were evident from the water analyses (Table 26) were due to temporary conditions prevailing on the sampling occasions. This was also true of, for example, the Na content in the superficial soil layers.

B. *Phragmites communis*

The polyploid level of all *Phragmites* clones in the northern biotopes 18—25 was tetraploid (Table 28). In Norjesund the clones in biotopes 28—29 and 29 A were tetraploid, while the clones in the other biotopes were hexaploid.

The Norjesund reed-beds consisted of a mosaic of clones of different *Phragmites* types and there the conditions sought for in my planning of the ecologic investigations of *Phragmites* seemed to exist, viz., the occurrence of different types of stabilized clones growing together in an area of as uniform environmental conditions as possible. Unfortunately these conditions were not — as shown above — quite perfect with respect to the uniformity. This was,

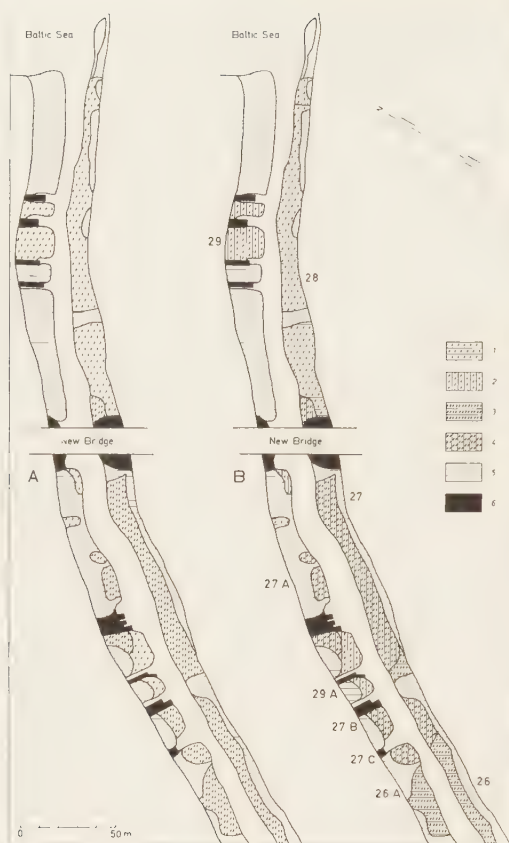


Fig. 85. The distribution in 1962 of different *Phragmites* types in the lower part of Norjesund. A. The distribution of *Phragmites* at tetraploid (single comma) and hexaploid (double comma) level. B. The distribution of *Phragmites* types within the polyploid levels: 1. Tetraploid type A. 2. Tetraploid type B. 3. Hexaploid type A. 4. Hexaploid type B. 5. Mixed stands and pure stands of other macrophyte species. 6. Filling and small bridges. Location of biotopes indicated by numbers.

on the other hand, compensated to some degree by the occurrence of stands of the same *Phragmites* type in different sites within the area.

In the lowermost part of Norjesund, the only one treated in this paper, each of the polyploid levels was represented by two different types, which, for practical purposes, are designated A and B.

The total distribution of *Phragmites communis* in Norjesund, the distribution of the tetraploid and hexaploid clones as well as of the four types with different habitus are shown in Figs. 75 and 85.

The hexaploid type A is represented by observations from biotopes 26 and 26 A, the hexaploid type B by biotopes 27 and 27 A—C, the tetraploid type A by biotope 28, and the tetraploid type B by biotopes 29 and 29 A.

The estimated percentages of apparently morphologically good pollen (Table 28) were within the range 70—90 in all clones growing in the northern biotopes and also in the clone in 28 Norjesund. In 29 Norjesund only 50 % of the pollen was estimated as good.

The pollen quality of the hexaploids was poor and in both clones the frequency of abnormal grains, especially grains with granulated exine, was high. Only about 5—10 % of the pollen was estimated as morphologically good.

The smallest pollen grains were regularly found in the lateflowering tetraploid clone in 22 Orlunden, mean diameter about 26 μm (Table 29). In the other tetraploid clones the diameter was ca. 27—29 μm . In the measurements from 1955 to 1958 of pollen from biotopes 24—25 it is seen that the largest mean diameter was obtained in samples taken in early September, when the top parts, i.e., flowers with large pollen grains, of the panicles were in new flower, while the small diameters refer to samples from panicles from which the large grains had blown away.

The pollen of the hexaploid clones was markedly larger; diameter 32 μm or greater. In Norjesund the hexaploids had,



Fig. 86. Panicles and shoots from biotopes in the Orlunden-Norjesund region. The biotope 19 panicles and shoots from 1962 and 1966. Biotope 20 represented by PS and WPS.

TABLE 26. Water analyses.

Biotope	Date	SW IWP, IWS	Samp- ling level cm	Water, Pit depth cm	θ °C	Col Pt mg/l	Sp.cond. µS	pH	Na	K	Mg	Ca	Fe	Cl	P	Alk		
									µmol/l							µeq/l		
18 Vitavatten	631122	SW	0	20	5.3	55	70	4.7	250	17	70	120	6	215	0.3	.		
	651001	SW	0	50	.	5	54	6.4	190	15	40	100	1	195	.	48		
	631030	SW	0	45	5.7	25	91	6.6	300	39	90	210	6	345	0.9	216		
	651001	SW	0	45	.	20	97	6.7	280	28	80	250	4	365	.	252		
19 Vångasjön	630805	IWS	18	.	14.4	120	140	.	450	51	190	290	89	580	9.1	.		
			35	.	13.2	60	150	.	420	40	140	340	27	580	4.8	.		
			53	.	12.2	100	160	.	440	46	170	380	46	585	4.6	.		
			76	.	11.2	100	170	.	460	31	190	390	43	585	3.7	.		
	640909	IWP	93	.	10.5	90	160	.	430	27	190	380	37	600	6.7	.		
			117	.	10.2	120	130	.	450	30	130	300	48	600	5.4	.		
			- 7	18	12.3	30	160	5.4	390	105	130	360	8	530	.	.		
			631030	SW	0	45	6.1	25	91	6.5	280	42	70	210	.	350	1.3	212
20 Vångasjön	630805	IWS	651001	SW	0	30	.	20	93	6.7	280	28	80	250	3	365	.	250
			640909	IWP	- 4	15	13.3	25	120	5.6	380	55	100	310	6	675	.	366
			631030	SW	0	55	.	20	98	6.7	280	28	80	250	4	370	.	254
			640814	IWP	-25	45	15.0	600	130	6.4	500	100	240	260	230	190	.	1060
22-23 Orlunden	631212	SW	0	65	1.5	50	78	6.3	260	41	80	170	9	280	.	76		
	640814	SW	0	20	18.7	20	83	7.0	250	42	60	190	2	295	.	102		
23 Orlunden	631212	IWS	640814	SW	10	.	4.5	.	92	6.8	350	56	140	75	315	.	.	
	640814	SW	60	.	6.7	.	9.1	.	100	7.1	390	76	150	170	24	325	.	.
24 Grånåm	631212	SW	0	75	1.5	50	87	6.4	290	54	90	180	9	295	.	96		
	640814	SW	0	40	14.0	20	100	7.0	280	44	90	250	3	315	.	270		
25 Håkantorp	631212	SW	0	75	1.5	45	81	6.4	270	42	80	170	8	290	.	82		
	640814	SW	0	15	15.2	15	88	6.9	260	42	60	200	2	310	.	126		
	630529	IWP	-22	50	9.4	.	350	6.3	1000	30	390	840	.	810	.	.		
	630627	IWP	-16	50	12.6	25	700	6.2	2400	58	720	1800	.	2240	.	900		
26 Norjesund	630801	SW	0	15	19.9	50	1000	7.0	6300	350	780	930	13	7420	4.7	996		
	630802	IWP	-10	45	14.3	80	1500	6.0	7600	120	1500	2700	25	10700	6.0	1750		
	630928	IWP	0	35	10.9	50	970	6.8	6100	360	820	930	8	6750	2.4	804		
	631030	SW	0	20	6.6	35	400	6.5	1400	150	440	820	7	1490	1.2	248		
26A Norjesund	630928	IWP	-10	35	10.5	50	1100	6.2	7500	320	820	890	7	7880	2.4	440		
	630529	IWP	-11	40	10.4	.	480	6.3	1900	110	330	970	.	2350	.	.		
	630627	IWP	- 8	50	13.1	30	910	6.1	4000	110	700	1800	.	5220	.	1020		
	630801*1	SW	0	20	19.0	50	1200	6.9	7600	330	930	890	9	9050	2.6	.		
27 Norjesund	630801*2	SW	0	20	19.8	50	1300	7.0	8800	360	960	820	11	10100	4.3	.		
	630817	SW	0	11	16.3	35	1600	6.9	11000	420	1400	890	.	12600	3.3	822		
	630927	IWP	-10	40	11.6	35	1200	6.3	7200	210	1200	1400	7	9100	2.4	1860		
	631030	SW	0	28	6.4	20	640	6.4	2800	220	690	1100	6	3120	3.0	214		
27C Norjesund	630928	IWP	- 4	35	10.9	35	1200	6.6	7600	390	1100	1000	5	8670	1.5	1140		
	630529	IWP	-17	50	11.6	.	420	6.5	930	120	320	1300	.	1050	.	.		
	630627	IWP	-15	50	12.5	15	950	6.3	4800	170	590	1700	.	6300	.	1050		
	630730	SW	0	23	15.6	20	8800	6.9	71000	1800	8500	2100	7	83900	3.2	1400		
28 Norjesund	630801	SW	0	25	20.2	45	1900	7.2	14000	500	1600	1100	9	16000	2.6	1110		
	630927	IWP	-16	40	11.2	15	810	6.5	3300	200	520	2100	2	4580	1.3	2240		
	631030	SW	0	35	6.3	25	1000	6.5	5900	270	890	1200	10	6480	3.9	1020		
	630529	IWP	-12	40	13.6	.	330	6.5	830	100	310	890	.	575	.	.		
29 Norjesund	630627	IWP	- 7	40	13.3	25	1200	6.3	6700	140	930	2000	.	8900	.	1670		
	630730	SW	0	12	15.7	20	7800	6.9	63000	1600	7400	2000	6	74300	4.1	1330		
	630801	SW	0	14	20.5	35	3100	7.1	23000	780	1900	1600	8	27200	3.2	1210		
	630927	IWP	-15	35	11.7	30	1800	6.5	13000	340	1300	1700	3	14900	0.9	2940		
631030	SW	0	20	6.6	30	880	6.6	5100	300	820	940	6	5890	3.0	292			

*1 = h 10.45. *2 = h 17.45.

TABLE 27. Water analyses from the lower part of Western Orlundsån, the Vesan canal and Norjesund. Samples from the superficial water layer.

Sampling station	Date	θ °C	Tr cm	Col Pt mg/l	KMnO ₄ ⁻ const. mg/l	pH	µS	Cl µmol/l	(O ₂)±
Western Orlundsån, 100 m upstream from the junction with the Vesan canal	550804	19.7	.	35	61	7.1	160	620	109
	550928	11.4	.	20	45	7.1	180	590	82
	551027	5.4	.	30	240	6.9	570	1320	18
	551125	0.1	.	60	390	6.7	450	990	20
	560503	5.8	.	40	55	6.9	130	480	100
	560908	17.0	.	25	44	7.8	170	540	99
	561029	4.2	.	35	170	6.7	260	680	14
The Vesan canal, 100 m upstream from the junction with Wes- tern Orlundsån	550930	12.3	.	10	46	6.8	600	2060	76
	551027	5.5	.	5	87	6.7	750	2060	16
	551125	0.1	.	40	450	6.2	990	2390	22
	560503	5.4	.	5	71	4.8	860	1970	83
	560908	16.8	.	20	36	7.5	500	1970	108
	561029	4.2	.	50	190	6.5	760	1770	43
	550804	21.4	.	20	85	7.0	5550	52400	121
Norjesund, 200 m upstream from the Baltic	550928	13.1	>150	10	48	6.8	940	6320	73
	551027	5.5	70	50	230	6.8	4980	44700	23
	551125	0.2	100	10	270	6.8	2120	86800	39
	560503	5.2	90	5	61	5.8	510	1230	80
	560908	15.5	>150	20	42	6.8	840	6740	89
	561029	4.4	20	50	250	6.7	880	4710	39

TABLE 28. Polyploid level and pollen quality.

Biotope	Polyploid level	Pollen quality	
		(F)	(D)
18 Vitavatten	4x	.	75
19 Vångasjön	4x	72	.
20 Vångasjön	4x	73	.
21 Vångasjön	4x	.	70
22 Orlunden	4x	.	70
24 Grännum	4x	.	90
25 Håkantorps	4x	.	85
26 Norjesund	6x	5	.
26A Norjesund	6x	.	.
27 Norjesund	6x	.	10
27A Norjesund	6x	.	.
27B Norjesund	6x	3	5
27C Norjesund	6x	8	5
28 Norjesund	4x	.	80
29 Norjesund	4x	.	50
29A Norjesund	4x	.	.

TABLE 29. Biometric analyses of pollen.

Biotope	Date	Pollen diameter						Pollen volume			
		n	m	e	µm	s	min	max	100 µl	min	m
18 Vitavatten	560909	675	27.5	0.07	1.71	20.7	35.1	47	110	228	
	570923	675	27.4	0.05	1.41	22.5	33.3	60	108	195	
	580911	675	28.0	0.07	1.91	21.6	32.4	53	115	178	
19 Vångasjön	620925	225	27.4	0.11	1.69	23.8	32.2	71	108	175	
	640909	225	27.9	0.11	1.68	23.8	32.2	71	115	175	
20 Vångasjön	620925	225	27.9	0.10	1.57	24.5	32.2	78	115	175	
	640909	225	27.7	0.09	1.38	24.5	30.8	78	113	153	
21 Vångasjön	560909	675	28.5	0.07	1.84	21.6	36.0	53	123	244	
	570923	675	27.3	0.06	1.69	21.6	32.4	53	108	178	
	580911	675	29.0	0.06	1.47	23.4	36.0	67	128	244	
22 Orlunden	550929	675	25.9	0.06	1.45	20.7	30.6	47	92	150	
	561021	675	26.5	0.09	2.22	18.9	35.1	36	99	228	
	570923	675	26.4	0.06	1.57	21.6	33.3	53	96	195	
	591001	225	26.1	0.09	1.33	23.8	30.1	71	94	144	
24 Grännum	550929	675	27.4	0.05	1.28	21.6	31.5	53	108	165	
	560909	675	29.2	0.07	1.84	20.7	36.0	47	130	244	
	570923	675	27.2	0.05	1.20	22.5	30.6	60	105	150	
	580911	675	29.5	0.06	1.67	22.5	35.1	60	136	228	
	600902	225	27.7	0.09	1.34	23.8	31.5	71	113	165	
25 Håkantorps	630911	225	28.0	0.10	1.44	23.8	32.2	71	115	175	
	550930	675	27.7	0.07	1.74	22.5	33.3	60	113	195	
	560910	675	29.2	0.08	2.01	23.4	36.0	67	130	244	
	570923	675	27.6	0.07	1.69	21.6	33.3	53	110	195	
	580911	675	29.4	0.08	2.14	20.7	38.7	47	133	306	
26 Norjesund	600902	225	27.7	0.10	1.48	24.5	31.5	78	113	165	
	630911	225	28.3	0.10	1.47	24.5	31.5	78	120	165	
	621005	225	34.6	0.16	2.43	30.1	48.0	144	217	579	
26A Norjesund	600923	225	32.5	0.14	2.05	28.0	37.8	115	181	283	
27 Norjesund	580912	675	34.4	0.08	2.05	28.8	45.0	125	213	477	
	630829	225	31.9	0.11	1.62	29.4	36.4	133	172	253	
27A Norjesund	600902	225	33.5	0.11	1.60	30.1	37.8	144	199	283	
	550928	675	32.2	0.08	2.13	27.0	37.8	103	175	283	
27B Norjesund	560908	675	33.1	0.08	2.03	27.0	40.5	103	192	351	
	570923	675	32.6	0.08	2.11	27.0	43.2	103	181	422	
	580912	675	33.5	0.09	2.21	26.1	44.1	94	199	452	
	600902	225	33.2	0.10	1.57	29.4	38.5	133	192	301	
	620912	225	33.8	0.11	1.64	30.1	37.8	144	202	325	
27C Norjesund	550928	675	32.2	0.09	2.25	26.1	39.6	94	175	325	
	560908	675	32.3	0.08	1.97	27.0	39.6	103	178	325	
	570923	675	32.4	0.08	2.18	26.1	37.8	94	178	283	
	580912	675	33.5	0.08	2.03	27.0	42.3	103	199	399	
	600902	225	33.2	0.11	1.69	29.4	37.8	133	192	283	
28 Norjesund	620912	225	33.7	0.13	1.88	29.4	38.5	133	202	301	
	570923	675	27.1	0.07	1.76	21.6	36.9	53	105	265	
	580912	675	28.7	0.07	1.82	21.6	34.2	53	125	210	
	620925	225	27.5	0.11	1.58	23.8	31.5	71	110	165	
	630829	225	26.5	0.09	1.31	23.8	30.1	71	99	144	
29 Norjesund	620906	225	28.1	0.10	1.51	24.5	32.2	78	117	175	
	630829	225	26.6	0.11	1.59	22.4	30.8	59	99	153	
29A Norjesund	620912	225	28.2	0.10	1.45	24.5	31.5	78	117	165	

TABLE 31. Biometric analyses of shoots.

31. Biometric analyses of shoots.																																													
Biotope	Date	Sampling method (no.) and area (m ²)	Shoot type	Number of shoots	Shoot length cm			Dist. base-1st green leaf, cm			Panicle length cm			Diameter of base internode mm			Diameter of internode at 1st green leaf, mm			Number of internodes per shoot			Internode length cm			Number of green leaves per shoot			Leaf length cm			Leaf breadth mm			Leaf area, dm ² per shoot PS resp. WPS			per m ² PS resp. WPS + BS							
					m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	PS	WPS	PS	WPS	PS	WPS		
18 Vitavatten	570923	1	PS	16	154	4.94	19.8	75	3.73	14.9	21.6	0.91	3.63	5.4	0.22	0.87	3.6	0.13	0.54	18.1	0.37	1.48	289	7.4	0.15	2.57	10.0	0.26	1.03	160	28.3	0.30	3.75	160	18.0	0.28	3.55	2.9	.	.	.	.	.		
	580911	1	PS	16	159	1.70	6.78	90	3.25	13.0	18.9	0.48	1.91	5.2	0.18	0.72	3.5	0.10	0.41	16.3	0.19	0.77	260	8.5	0.24	3.83	8.5	0.28	1.10	136	28.9	0.33	3.80	136	18.2	0.33	3.81	2.6	.	.	.	.	.		
	590921	1	PS	16	158	3.92	15.7	81	2.35	9.45	22.2	0.56	2.25	5.3	0.16	0.66	3.7	0.16	0.64	18.1	0.44	0.89	290	7.4	0.16	2.72	10.2	0.34	1.38	163	29.0	0.35	4.35	163	18.9	0.31	4.01	3.2	.	.	.	.	.		
	600923	1	PS	16	159	4.75	19.0	86	3.55	14.3	18.3	1.05	4.21	5.3	0.18	0.73	3.6	0.09	0.36	17.3	0.31	1.24	276	8.1	0.17	2.85	8.4	0.26	1.03	135	30.3	0.28	3.26	135	19.3	0.28	3.28	2.8	.	.	.	.	.		
	610918	1	PS	16	191	3.01	12.0	123	2.57	10.3	20.0	0.48	1.90	6.5	0.04	0.15	3.5	0.11	0.42	18.1	0.40	1.61	289	9.5	0.21	3.60	7.3	0.49	1.95	122	32.5	0.35	3.89	122	21.5	0.37	4.05	3.0	.	.	.	.	.		
19 Vångasjön	621015	3/4	WPS	8	141	16.7	47.3	115	6.08	17.3	.	.	.	6.6	0.52	1.46	3.9	0.31	0.81	16.3	1.84	5.20	130	8.3	0.32	3.60	7.9	1.20	3.40	63	29.1	0.48	3.78	63	20.2	0.49	3.86	2.7	5	.	.	4	.		
			WPS	5	138	10.7	23.8	109	4.64	10.4	.	.	.	5.5	0.54	1.21	3.2	0.25	0.56	17.0	1.09	2.45	85	7.7	0.36	3.28	8.0	0.94	2.11	40	29.2	0.58	3.67	40	19.6	0.68	4.29	2.7	3	.	.	3	.		
			WPS	7	112	9.57	25.3	86	8.48	22.4	.	.	.	4.8	0.50	1.31	2.8	0.32	0.86	15.3	0.92	2.43	107	7.0	0.33	3.44	7.3	0.89	2.36	51	25.9	0.74	5.26	51	17.1	0.51	3.66	2.0	3	.	.	3	.		
	610918	1	PS	15	268	1.46	5.83	160	2.66	10.6	30.6	0.39	1.55	8.6	0.26	1.05	5.9	0.12	0.47	17.6	0.18	0.73	281	13.5	0.35	5.86	8.2	0.16	0.66	131	44.7	0.38	4.32	131	26.2	0.38	4.38	5.0	.	.	.	.	.		
	620925	3/1	WPS	39	271	3.26	20.3	132	1.86	11.6	27.8	0.38	2.30	8.5	0.20	1.24	6.5	0.12	0.77	19.6	0.26	1.65	762	12.1	0.19	5.16	10.7	0.13	0.79	418	45.5	0.22	4.49	418	29.5	0.26	5.23	7.7	299	.	.	312	.		
20 Vångasjön	630921	3/1	PS	52	287	2.13	15.4	185	2.00	14.4	26.4	0.48	3.49	9.0	0.17	1.24	5.3	0.09	0.67	19.7	0.19	1.06	630	12.8	0.26	6.62	8.5	0.12	0.90	444	38.2	0.22	4.59	444	28.6	0.27	5.60	6.0	314	.	.	.	.	.	
			WPS	5	218	4.85	10.8	176	6.60	14.8	.	.	.	7.8	0.41	0.91	4.1	0.39	0.86	17.6	0.19	1.06	630	12.8	0.26	6.62	8.5	0.12	0.90	444	38.2	0.22	4.59	444	28.6	0.27	5.60	6.0	314	.	.	.	.	.	
			WPS	5	285	4.64	10.4	158	4.00	8.94	31.4	1.12	2.51	8.8	0.22	0.50	6.4	0.19	0.42	17.6	0.51	1.14	.	.	.	.	8.8	0.49	1.10	44	48.0	0.87	2.49	44	31.6	0.77	5.08	5.9	223	.	.	241	.		
			WPS	4	215	.	.	151	.	.	.	.	.	6.9	.	.	4.7	.	.	17.5	.	.	.	.	.	.	.	8.3	.	.	33	42.7	0.79	4.57	33	24.5	0.74	4.23	4.6	18	.	.	.	.	.
	620925	3/1	PS	11	154	2.38	7.89	101	2.78	9.22	.	.	.	6.0	0.23	0.75	3.1	0.07	0.24	19.6	0.49	1.63	217	7.3	0.21	3.13	9.5	0.08	0.26	105	24.8	0.44	4.48	105	16.4	0.38	3.90	2.4	26	.	.	.	.	.	
21 Vångasjön	630921	3/1	PS	98	113	2.41	28.8	87	1.32	12.7	.	.	.	4.7	0.08	0.79	2.6	0.04	0.41	15.2	0.30	3.00	1494	7.1	0.07	2.78	6.6	0.27	2.63	667	22.2	0.18	4.74	667	14.2	0.13	3.46	1.3	130	.	.	.	.	.	
			WPS	5	171	7.24	16.2	102	5.27	11.8	16.0	.	.	6.4	0.40	0.90	3.1	0.15	0.34	18.6	0.09	0.20	93	8.4	0.34	3.29	10.0	0.45	1.00	50	25.8	0.68	4.82	50	16.4	0.58	4.10	2.5	13	.	.	.	.	.	
			WPS	85	115	2.60	24.0	90	1.64	15.1	.	.	.	4.9	0.09	0.86	2.1	0.05	0.48	17.6	0.40	0.90	88	7.1	0.33	3.11	7.0	0.28	2.60	597	22.2	0.23	5.55	598	13.1	0.15	3.64	1.3	109	.	.	.	.	.	
			WPS	5	199	4.90	11.0	114	4.85	10.8	15.6	0.51	1.14	6.4	0.25	0.56	3.9	0.12	0.27	18.4	0.24	0.55	.	.	.	.	10.0	0.32	0.71	50	31.7	0.76	5.35	50	20.6	0.77	5.45	3.4	45	.	.	.	.	.	
			WPS	5	137	3.54	7.91	95	1.12	2.50	.	.	.	4.6	0.15	0.34	2.6	0.13	0.30	18.0	0.45	1.00	.	.	.	.	9.2	0.38	0.85	44	25.8	0.84	5.53	44	15.8	0.58	3.84	1.7	116	.	.	.	.	.	
22 Orlunden	560909	1	PS	5	179	4.90	11.0	108	3.04	12.2	22.6	0.58	2.34	6.7	0.26	1.42	3.9	0.13	0.49	18.8	0.30	1.18	300	9.0	0.20	3.44	8.3	0.22	0.86	132	33.0	0.33	3.82	132	21.5	0.40	4.64	3.3	.	.	.	.	.		
	570923	1	PS	16	187	3.54	14.1	115	2.95	11.8	20.4	0.30	1.22	7.1	0.29	1.77	3.9	0.12	0.48	19.0	0.24	0.97	302	8.8	0.20	3.46	7.6	0.18	0.72	134	28.8	0.42	4.89	134	18.4	0.43	4.97	2.6	.	.	.	.	.		
	580911	1	PS	16	202	1.68	6.74	131	1.84	7.35	20.4	0.41	1.63	6.5	0.21	0.83	3.7	0.08	0.31	18.4	0.18	0.72	294	9.9	0.22	3.79	7.4	0.24	0.96	118	30.1	0.45	4.85	118	19.5	0.43	4.66	2.2	.	.	.	.	.		
	590921	1	PS	16	202	4.11	16.4	126	2.96	11.9	21.3	0.50	2.02	7.3	0.24	0.98	4.0	0.11	0.45	18.5	0.32	1.27	296	9.7	0.22	3.76	7.9	0.27	1.09	126	32.1	0.47	5.24	126	19.8	0.46	5.14	2.8	.	.	.	.	.		
	600923	1	PS	16	193	3.3																																							

TABLE 33. Standing crop (g/m^2).

Biotope	Date	Sampling area m ²	Shoot type	Shoots per m ²	Panicles			Leaves			Rest			Total			Stand. crop	
					FW	DM	AW	FW	DM	AW	FW	DM	AW	FW	DM	AW		
18 Vitavatten	621015	12	WPS BS	1.7 0.3	.	.	.	5.5 0.1	2.2 0.04	0.13	24 1.3	8.2 0.4	0.21 0.01	30 1.4	10 0.4	0.34 0.01	11	
	620925	2	WPS	34/1.5 ¹ 4	89/1.6 ² 33	2.4	495 29	159 7.8	17 0.91	1520 81	570 25	1.8 1.8	2110 81	760 33	48 2.7	793		
10 Vångasjön	630921	1	PS WPS DS	52 5 13	145 .	67 .	4.5 .	535 31	192 9.6	20 1.0	2150 135	780 41	46 2.6	2830 170	1030 50	71 3.7	1080	
	640909	1	WPS DS	38 4 1	134 .	56 .	4.2 .	415 30	151 11	16 0.47	1270 87	340 32	34 2.3	1820 120	750 43	54 2.7	793	
	620925	2	PS WPS DS	0/7.5 95 1.5	0.15 .	.	.	28 175	11 65	0.72 4.4	118 763	42 270	1.0 7.6	145 940	52 330	1.7 12.0	382	
20 Vångasjön	630921	1	PS WPS DS	3/2 85 15	0.83/0.05 .	0.36 .	0.01 .	19 140	7.5 53	0.50 3.7	80 700	30 250	0.84 5.9	100 840	38 290	1.4 9.6	328	
	640909	1	PS WPS DS	8/5 70 15	6.8/. .	2.6 .	0.17 .	71 157	29 70	2.3 4.9	295 712	100 238	2.8 7.3	370 869	130 308	5.3 12.2	438	
22 Örlunden	630911	3	WPS DS	11.3/4.7 0.3	3.1/0.15 .	1.4 .	0.07 .	61 4.7	23 1.6	1.5 0.10	196 23	87 8.3	3.2 0.34	260 28	111 9.9	4.7 0.44	121	
22-23 Örlunden	621015	1	PS WPS DS	10/17 .	2.1/0.28 .	0.76 .	.	76 15	31 6.0	1.7 0.30	508 171	206 55	7.1 2.0	586 186	238 61	8.8 2.3	299	
23 Örlunden	621015	2	PS WPS DS	0.5/3.5 22	0.07/0.05 .	.	.	22 48	9.6 19	0.77 1.1	118 459	43 138	1.5 4.8	140 507	53 157	2.3 5.9	210	
	621005	1	PS WPS BS DS	4/2 41 7 11	5.6/0.10 .	.	.	.	.	.	.	.	.	695 2795 355 (425)	.	.	(1240)	
26 Norjesund	630829	2	PS WPS BS DS	13.5/4.5 43 11 11.5	41/1.2 .	12 .	0.63 .	473 431 13	162 127 3.9	15 0.35	1793 2382 107	647 646 31	32 43 2.0	2308 283 177	820 775 35	48 54 4.8	1630	
	620912	1	PS WPS BS DS	33/4 24 8 8	105/1.4 .	.	.	.	.	.	.	.	.	3576 1320 512 (200)	.	.	(2007)	
	630917	1	PS WPS DS	13/2 21 13	228 .	0.13 .	80 .	4.5 .	570 148	216 56	16 4.2	3197 1067	1222 1363	55 19	3995 1215	1517 417	76 23	1934
27C Norjesund	630817	1	PS WPS BS DS	32/2 10 1 7	240/0.16 .	79 .	4.2 .	735 153 7	260 249 2.4	19 3.8 0.18	2875 817 73	1167 263 23	49 14 1.2	3850 9 80	1506 13 25	72 18 1.4	1842	
	620925	2	PS WPS BS DS	24/20 21 14 4.5	40/1.4 .	16 .	1.2 .	778 200 65	265 68 21	27 6.8 2.1	2358 593 363	1049 225 140	51 13 7.4	3178 793 428	1330 294 161	78 20 9.5	1785	
28 Norjesund	630829	2	PS WPS BS DS	44/5.5 18 13 10	182/2.2 .	60 .	3.9 .	756 105 3	273 34 1	23 3.0 0.09	3005 548 14	1132 152 4.5	44 9.0 0.22	3945 853 17	1465 182 5.5	71 12 0.31	1657	
	620912	2	PS WPS BS DS	45/5 57 3.5 6	17/1.5 .	8.6 .	0.52 .	428 249 14	160 86 4.2	13 6.9 0.33	1098 739 43	442 239 11	18 11 0.67	1543 988 57	610 325 18	31 1.0	954	
29 Norjesund	630829	2	PS WPS BS DS	45/3.5 49 9 22	38/1.0 .	17 .	1.1 .	402 299 29	142 64 8.9	16 7.6 0.68	1398 709 125	564 25.5 43	32 16 2.6	1838 978 154	722 326 55	49 24 3.3	1100	

1 - shoots with normal panicles/shoots with dry, undeveloped, and deformed panicles. 2 - normal panicles/dry etc. panicles.
3 - plant material in poor condition.

TABLE 35. Analyses of press-cakes from biotopes 19-20 Vångasjön. As for sampling date, environmental conditions at samplings etc. see corresponding sample numbers in Table 34.

Shoot part	Bio- type	Shoot type	Sample no.	Na ⁺ K Mg Ca Fe					
				mmol/100 g DM of press-cake					
Rhizomes	19	PS	22/63	3.05	26.2	1.4	0.38	0.11	
			58/63	2.53	21.3	1.0	0.32	0.13	
			115/63	2.62	21.0	1.3	0.37	0.18	
Lower leaves	19	PS	180/63	2.18	23.3	1.3	0.33	0.16	
			218/63	2.48	27.1	1.5	0.35	0.25	
			24/63	2.07	29.8	1.3	0.28	0.18	
Upper leaves	20	PS	62/63	2.18	24.4	1.3	0.28	0.16	
			117/63	1.95	20.7	1.5	0.28	0.14	
			174/63	1.14	22.1	1.4	0.32	0.13	
Shoot tips	19	PS	220/63	2.27	25.1	1.7	0.28	0.16	
			55/63	0.33	9.8	4.3	5.4	0.69	
			113/63	0.42	9.7	5.1	6.6	0.79	
Panicles	19	PS	178/63	0.56	10.4	5.9	7.5	0.66	
			59/63	0.24	9.1	6.1	6.3	0.61	
			121/63	0.21	12.9	2.7	1.8	0.42	
Shoot tips	20	PS	56/63	0.28	10.2	2.6	3.3	0.28	
			112/63	0.15	7.8	5.3	6.9	0.39	
			177/63	0.25	6.3	7.5	9.4	0.50	
Panicles	19	PS	217/63	0.30	13.1	7.8	11.3	0.58	
			20/63	0.20	13.1	3.8	3.0	0.49	
			60/63	0.37	10.5	2.9	3.5	0.21	
Shoot tips	20	WPS	116/63	0.25	13.1	3.4	3.7	0.22	
			172/63	0.28	9.8	4.1	4.1	0.27	
			173/63	0.28	9.8	3.3	3.9	0.38	
Panicles	19	PS	219/63	2.00	4.0	10.0	9.3	0.74	
			57/63	0.27	10.0	1.6	1.3	0.17	
			61/63	0.26	11.9	1.7	2.0	0.11	
Panicles	19	PS	114/63	0.25	11.7	2.5	2.0	0.21	
			179/63	0.71	24.1	6.3	3.9	0.29	

TABLE 34. Environmental conditions at samplings, description of samples for sap expression and analyses of whole samples, press-cakes and expressed sap.

Shoot part	Biotope	Shoot type	Sample no.	Date	h	Wind velocity	Cloudiness	Biotope in light, shadow etc.	Air temp. °C	Rh %	Water depth cm	Object dimensions				Insertion levels, cm				Whole sample			ES ml/kg FW	Press-cake			W 3 % of whole	Colour (Paclt 1958)			ΔT °C	Expressed sap			Na K Mg Ca Fe Cl P																																																																																																																																																																																																																																																																																																																																								
												Length, mm	Breadth, mm	Thickness mm	Lower leaf	Upper leaf	Lower leaf	Upper leaf	Lowest	Highest	Mean	Range		W 1 % of FW	DM 1 % of FW	A 1 % of FW		W 2 % of FW	DM 2 % of FW	A 2 % of FW		W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3		W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	W 1 % of DM 1	DM 1 % of A 1	DM 3 % of A 3	

from a volumetric point of view, ca. 75 % larger pollen grains than the tetraploids. The diameter of the pollen from the hexaploid clones was determined on grains which after the acetolysis had a morphologically normal appearance (Fig. 135).

The rhizosphere had the smallest vertical extension, about 70 cm, in 22 Orlunden (hard silty sand). In different gyttja types in Vitavatten, Vångasjön and Norjesund the extension exceeded 110 cm.

The panicle shoot length (Table 31, Fig. 86) in tetraploid clones amounted to about 1.5—2.0 m in 18 Vitavatten, 20—21 Vångasjön, and 22—23 Orlunden and to about 250—325 cm in 19 Vångasjön, 24 Gränum, 25 Håkantorp, and 28—29 Norjesund.

In all hexaploid clones the panicle shoot length was within the range 350—390 cm.

The variation in shoot dimensions is obvious also in the weight analyses (Table 32).

The leaf area per panicle shoot (Table 31) was in the tetraploids mostly about 2.5—3.5 dm² in the short-shooted clones in biotopes 18 and 20—23 and varied from 5—9 dm² in the tall-shooted clones in biotopes 19, 24—25, and 29.

In the hexaploids the leaf area of the corresponding shoots was 15—20 dm².

The mean length of the stomatal guard-cells (Table 30) of the middle leaves rarely exceeded 25 µm in the tetraploids, while in the hexaploids the length was 28—30 µm. The density of the stomata was for the most part definitely higher than 1000 in the tetraploids but below or about 1000 in the hexaploids.

The shoot density in the tetraploid clones was 2 in 18 Vitavatten, 20—50 in 19 Vångasjön and 22—23 Orlunden, 50—75 in 21 Vångasjön, 24 Gränum, and 28 Norjesund and about 100 in 20 Vångasjön and 25 Håkantorp. The highest density, viz. 130, occurred in 29 Norjesund.

In most hexaploid clones the shoot density was within the range 50—60.

Very great variations in the panicle frequency were found among the tetraploid clones, viz., from 10—25 % in 18 Vitavatten (in 1962 less than 1 %, in other years up to 25 %), 20—21 Vångasjön and 23 Orlunden to 90 % in 19 Vångasjön and 25 Håkantorp. The earliest flowering occurred in biotope 29 Norjesund and the latest, at least one month later, in 22 Orlunden.

In the hexaploids the panicle frequency was 30 % in type A and 60 % in type B, which flowered about one month earlier than type A.

The total leaf area in tetraploid clones was only 4 dm²/m² in 18 Vitavatten, 30—65 in 22—23 Orlunden, 150 in 20 Vångasjön, 300 in 19 Vångasjön and about 450 in 29 Norjesund. The corresponding figures for standing crop in these biotopes were 11, 120—300, 380, 890, and about 1000 g. In 28 Norjesund it was ca. 1700 g.

In the hexaploids the total leaf area was 600 dm²/m² in 26 Norjesund (type A) and 340—390 in 27 and 27 C Norjesund (type B, areas calculated from weights). The standing crop was about 1500 to 2000 g for both types.

The analyses of expressed sap and press-cakes (Tables 34—35) are discussed in the Synthetic Part.

IV. Biomes within Eutrophic Regions in South Sweden and Zealand

Of the six investigated lakes Jägern is situated in the province of Södermanland, Tåkern in Östergötland, Western Ringsjön, Krankesjön, and Björkesåkra-sjön in Scania (Skåne), all in South Sweden, and Tystrup Sö in Southwestern Zealand (Sjælland). See the maps in Figs. 4 and 87.

The heterogeneity with respect to environmental conditions and *Phragmites* material of the biomes 30—39 treated here under one heading is discussed in the summary of the analyses p. 154 ff.



Fig. 87. Topographic maps of the areas around the lakes with biomes 30—39 within eutrophic regions. Compare Fig. 4.

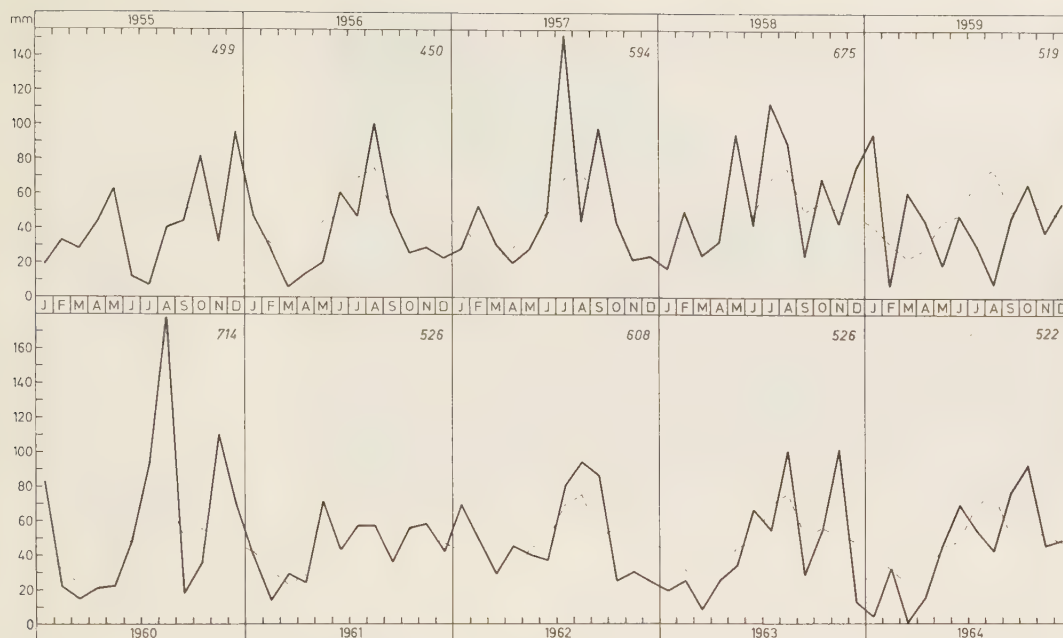


Fig. 88. Precipitation per month (solid line) and monthly mean precipitation for the period 1955—1964 (broken line) for Katrineholm, situated 10 km southwest of Lake Jägern. Top right figures for yearly precipitation.

Lake Jägern

With Biotopes 30 and 31 A—D

General Description

59°4'N, 16°20'E. Altitude 27 m a.s.l. Area 0.9 km². Max. depth 2 m.

The bedrock within the region consists of Archaean veined gneisses. The province of Södermanland as a whole is situated below the highest shore line. In connection with the land uplift the clayey moraine was washed out by the surf from the highest parts and clayey deposits were formed in the submerged lower parts. Thus a landscape constituting a mosaic of washed higher areas of oligotrophic character and lower areas with clayey sediment deposits of eutrophic character was developed (FLORIN 1957).

The influence of the local bedrock on the fertility of the soils around Jägern is unfavourable or only to some degree favourable. However, in the valleys the fertility of the fine-grained soils is good because, among other things, some transportation from the north to this area of disintegrated rocks con-

taining lime has taken place. The cultivated surface soils are designated light intermediate clay. The lower areas are cultivated, while the higher are covered by forests (pine and spruce). Around Jägern the forest areas constitute ca. 60 % (40—80 %) of the total land area. The main part of the immediate surroundings of Jägern consist of cultivated ground.

Climatic conditions are shown in Figs. 5—6 and 88.

Lake Jägern belongs to the watercourse system of the river Nyköpingsån. The water level of the lake was permanently lowered during the nineteenth century and the organogenic sediments nowadays reach the water surface in several shore areas.

According to THUNMARK (1952) the transparency in Jägern varied from 130 to 150 cm during the summer in the period 1946—1951. In the superficial layer of the pelagic water the mean of the specific conductivity was 110 μ S and for pH 7.2. In Aug. 1955 and Sept. 1957 the present author obtained the following data: Tr 130/170, Col 35/40, Sp. cond. /120 μ S, and pH 7.5/7.2.



Fig. 89. Biotope 30 Jägern
— Photo S. Björk 630822.

By THUNMARK (op.c.) Jägern is characterized as a highly eutrophic lake. He reports 35 hyperhydate, 10 ephydate, and 19 hyphydate species. The presence of the following constellation of macrophyte species is considered as a definite sign of the eutrophic character of the lake, viz., the hyperhydrites *Butomus umbellatus*, *Ranunculus lingua*, *Rumex hydrolapathum*, *Sagittaria sagittifolia*, and *Sium latifolium*, the ephydates *Hydrocharis morsus-ranae*, *Ricciocarpus natans*, *Spirodela polyrrhiza*, and the hyphydates *Lemna trisulca*, *Riccia fluitans*, *Ceratophyllum demersum*, and *Myriophyllum spicatum*.

Jägern is surrounded by broad dense reed-beds of *Equisetum fluviatile*, *Phragmites communis* (most prominent), *Scirpus lacustris*, *Typha angustifolia*, and *T. latifolia*. Notes on standing crop and biometric conditions of *Equisetum fluviatile* are given by BJÖRK (BJÖRK & DIGERFELDT 1965). Plaur formations with well-developed parafyllion are common (THUNMARK op. c., p. 107).

The ephydate vegetation is dominated by luxuriant stands of *Nuphar luteum* and *Nymphaea alba*. In some years considerable bottom areas were covered by elodeids, above all by *Ceratophyllum demersum* but also by *Potamogeton obtusifolius*, *Myriophyllum spicatum* and *M. verticillatum*. The only isoetid noted from Jägern is *Eleocharis acicularis*.

Biotope 30

A. Environment

Situation (Fig. 87). 20 m outside the middle part of the southern shore of the bay west of Kalsta.

Physiographic survey (Fig. 89). The bay is totally overgrown by *Phragmites*. The reed-bed also surrounds the island situated 200 m from the innermost part of the bay. Around the bay there is cultivated ground, but along the shore there is a zone with *Salix* and *Alnus* bushes.

The biotope was sheltered against winds from all directions except from the west. No wave action was noticeable. It was over-shadowed in early morning in late summer and autumn.

Just outside the bush belt was a zone with *Carex elata* intermingled with *C. riparia*, *Iris pseudacorus*, *Lythrum salicaria*, *Lysimachia thyrsiflora*, and *Sagittaria sagittifolia*.

In openings in the reed-bed the water surface was covered by *Hydrocharis morsus-ranae*, *Lemna minor*, and *Spirodela polyrrhiza*. *Lemna trisulca* was also frequent. The same species were also scattered within the reed-bed.

Most of the dry *Phragmites* stems were broken in the spring and during the vegetation period they formed a fairly dense layer above the water surface.

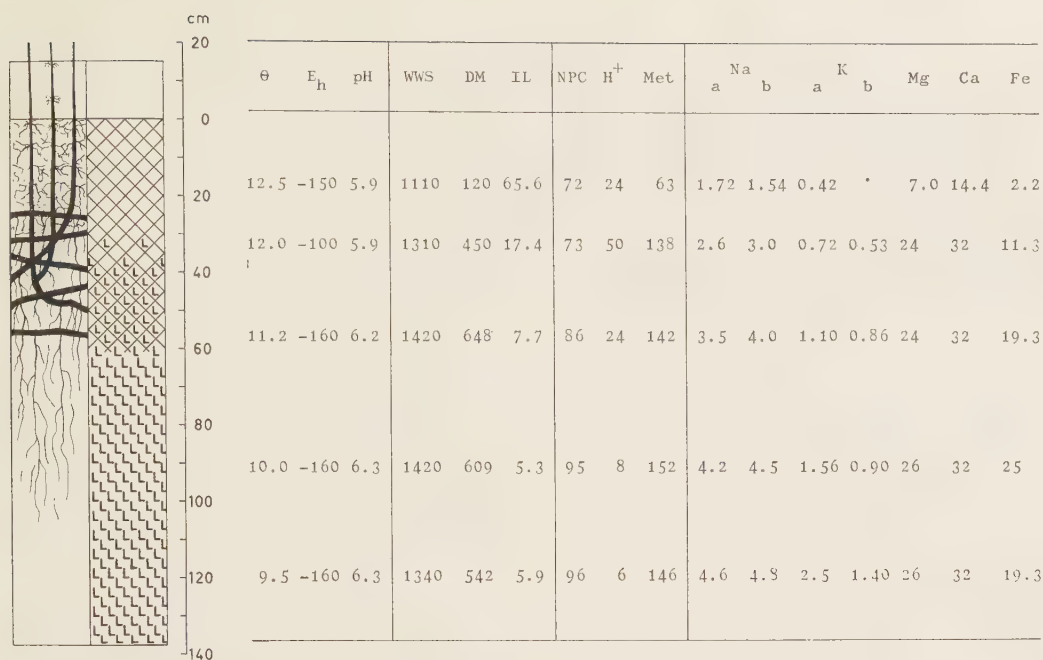


Fig. 90. Biotope 30 Jägern 630822. Vertical section and soil analyses.

The water (Table 36). On sampling occasions in July to Sept. in 1957, 1960, and 1962 the water depth varied from 15 to 55 cm. In Sept. 1957 the following water quality data were obtained in four sampling squares (water depth 34—54 cm): Col. 40—50, Sp.cond. 114—119 μ S, pH 6.3—6.4, Cl 210—240 μ mol/l, and $(O_2)s$ 10—22 ‰. In July 1962 the conductivity was 92 μ S (water depth 30 cm) and in Aug. 1963 89 μ S (water depth 15 cm). On the latter occasion the Cl content was as low as 100 μ mol/l.

Already these observations indicate the scheme which is applicable to biotopes similar to that in Jägern. At high water level, especially in the spring when there is a lively exchange of water between the reed-bed and the open lake, the water quality in the biotope resembles that in the lake, but the lower the water level during the vegetation period, the greater the difference between the water in the

open lake and in the biotope. This is plainly recorded in the specific conductivity which gradually becomes lower in the reed-bed. Of course, the reed-beds which are supplied with subsoil water from the surroundings or from below are not included here.

The bottom (Fig. 90). The surface was covered by a 5 cm thick layer of very coarse *Phragmites* detritus. The accumulation of organic matter was considerable.

Stratigraphy:

- 0— 29 cm Brown, loose, coarse gyttja.
- 29— 37 cm Greyish clayey gyttja.
- 37— 52 cm Brown clay gyttja.
- 52— 61 cm Brown grey clay gyttja.
- 61—138 cm Grey heavy clay with high water content.

In comparison with *Phragmites* biotopes in southernmost Sweden the bottom temperature was lower. At 115 cm it was, at the end of Aug., as low as

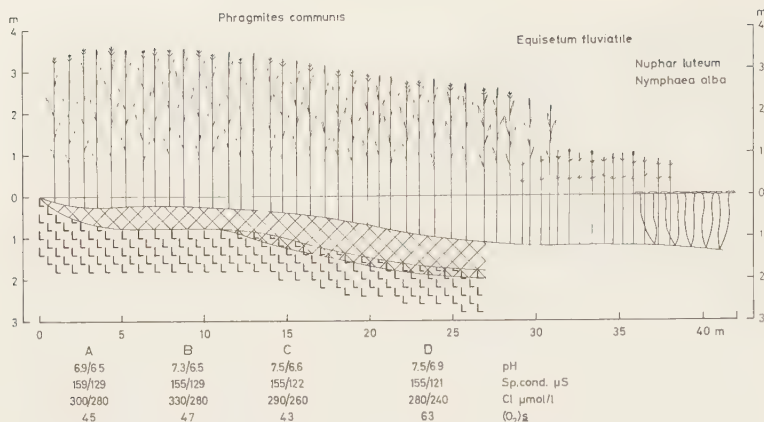


Fig. 91. Section through the reed girdle in Lake Jägern (1955). A—D indicate sampling sites for shoots (analyses in Table 40). Surface water analyses (below) from 550818/570912, values for (O₂)s from 1957 only.

9.5°C. The surface layer of the bottom in the sheltered bay is rapidly warmed up in the spring, but later on it is overshadowed by the *Phragmites* shoots (final length ca. 4 m, leaf area ca. 280 dm²/m²) and the warming up is retarded. The preservation of low temperatures causes a retardation of the mineralization processes, which is accompanied by an accelerated growth of voluminous detritus deposits.

In the clay and the clay gyttja the pH was higher than in the young organogenic deposits. The percentage of neutralization increased downwards from the organogenic to the minerogenic soil. The amounts of extractable Na and K also increased downwards, while Mg and Ca showed low concentrations in the upper layer and then were fairly stable throughout the section.

B. *Phragmites communis*

Rhizomes and roots (Fig. 90). Horizontal rhizomes were observed from 25 to 75 cm. The rhizomes occurring between 60 and 75 cm were, however, probably dead. Fine roots occurred down to at least 100 cm. In the loose clay they were noticeably long, thin and delicate.

A dense felt of fine roots from vertical rhizomes was developed down to 25 cm. Only one or two of the lower nodes of some of the shoots had fine roots. (Dead *Equisetum* rhizomes and roots occurred in the whole soil section.)

Shoot density. Ca. 25.

Flowering time. The long and bushy panicles were in full flower in the first to second week in Sept.

Panicle frequency. Ca. 80 %.

Further data in Tables 37—39, 41—44.

Biotopes 31 A—D

A. Environment

For biometric analyses horizontal sections were laid out through the reed girdle perpendicular to the eastern shore of Jägern south of the Ökna estate (Figs. 87 and 91). The breadth of the *Phragmites* girdle was 33 m. From 29 to 33 m there was an outwardly increasing intermingling with *Equisetum fluviatile*, which alone formed the outer 5 m broad margin of the hyperhydate vegetation. Further lakewards the ephydate zone was made up of *Nuphar luteum* and *Nymphaea alba*.

The landward margin for the *Phragmites* reed-bed was at the water line. Above this was a zone with *Carex elata*, *C. lasiocarpa*, *C. rostrata*, *Cicuta virosa*, *Lythrum salicaria*,

Potentilla palustris, and single shoots of *Phragmites communis* and *Typha latifolia*. This zone was followed by a girdle of *Alnus* and *Salix* bushes behind which there was cultivated ground. The biotopes were exposed to westerly winds, but no wave action was noticeable there.

Two sections were analysed, one in 1955 and one in 1957. In 1957 the section was laid out parallel to and immediately north of the first one (water depth 15 cm greater than in 1955). In each year four squares of 1 m² were used. The intermingling with other plant species was weak in the sampled squares. The following species were noted: *Cicuta virosa*, *Equisetum fluviatile*, *Hydrocharis morsus-ranae*, *Lemna minor*, *Potamogeton obtusifolius*, *Ricciocarpus natans*, *Spirodela polyrrhiza*, *Typha angustifolia*, *Utricularia vulgaris*.

Dry erect *Phragmites* stems were found only in the landward zone.

The quality of the water in the outer zone of the girdle did not differ much from that of the pelagic water with respect to specific conductivity, pH, and Cl content. The inner zone, to some degree furnished with subsoil water, had somewhat higher conductivity, lower pH, higher Cl content, and lower oxygen saturation (Fig. 91).

The bottom consisted of coarse gyttja above a layer of clay. Between these layers there was from 12 m from the shore and lakewards a clay gyttja layer. The thickness of the gyttja in squares B—D from 1957 was 20 cm greater than in the squares from 1955.

B. *Phragmites communis*

Rhizomes and roots. The lowest noted depth for roots was 120 cm in the middle part of the section, i.e., the roots reached the clay.

Further data in Table 40.

Additional notes. The horizontal sections described from Jägern are representative of many shallow eutrophic lakes. With respect to different shoot qualities and standing crop *Phragmites* has a characteristic maximum in the landward half of the reed girdle.

In Jägern the water depth at the outer margin of *Phragmites* stands varied from

102 to 112 cm (1955). The corresponding depths for *Equisetum fluviatile* was 106 and 119 cm.

It is evident that in a reed girdle of the Jägern type the best environmental conditions for *Phragmites* are realized in the inner part, at some distance from the shore. Though the Jägern section type is characteristic of many lakes, there are, however, several other types too. As is well known, a *Phragmites* stand conformous with the shore fairly often has very sharp outer and inner limits and does not show any noticeable gradient with respect to shoot size and standing crop along a section perpendicular to the shore. The reason for the sharp delimitations may in some cases be ice and frost action.

Lake Tåkern

With Biotope 32

General Description

58°21'N, 14°49'E. Altitude 93 m a.s.l. Area 44 km². Max. depth < 2 m, only in a small area is the depth > 1 m.

South of the lake the Archaean bedrock consists of granite. The basin is a shallow depression in Cambro-Silurian sandstone, shales and limestone, the latter constituting the bedrock north of the lake. The Cambro-Silurian bedrocks have a favourable to very favourable influence on the fertility of the soil.

The western part of the Östergötland plain, to which Tåkern belongs, is a practically totally cultivated district. Under the superficial sandy moraine clay there is a layer of intermediate moraine clay. The former southwestern bay of Tåkern is developed as a mire (nowadays culturally influenced) with ca. 2 m *Sphagnum* peat, the mire Dagsmosse.

General descriptions of the lake, investigations concerning the vegetation and special elements of the fauna are given in SJÖN TÅKERNS FAUNA OCH FLORA, (1929, published by the Royal Swedish Academy of Sciences) and in DU RIETZ *et al.* (1939). Hydrographic conditions are described by MELIN (1928).

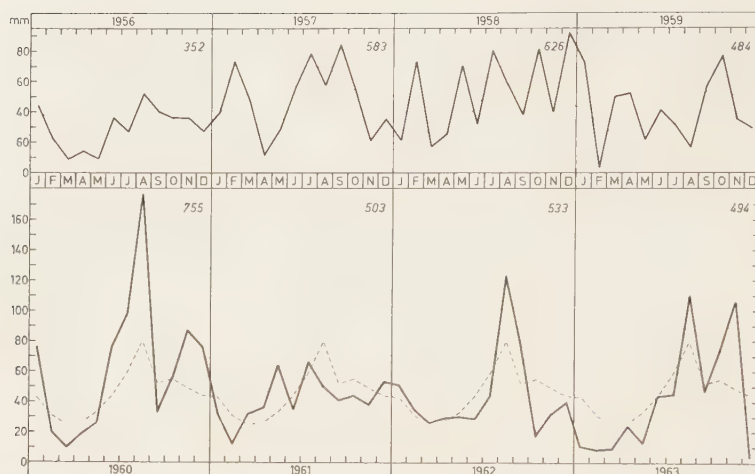


Fig. 92. Precipitation per month (solid line) and monthly mean precipitation for the period 1956—1963 (broken line) for Vadstena, situated 10 km north of lake Tåkern. Top right figures for yearly precipitation.

The changes in the development of the elodeid vegetation are dealt with by THOMAS-SON (1955), LOHAMMAR (1965 a) and reviewed by FORSBERG (1964 a), who considers the rise in the phosphorus content of the water to be the reason for the disappearance of the charophytes (FORSBERG 1964 b). Water analyses are given by LOHAMMAR (in DU RIETZ *et al.* op.c.) and FORSBERG (1964 a). LOHAMMAR (1965 b) also pointed out the effect of the plant metabolism on the quality of the water in stands of elodeids etc. According to LOHAMMAR (1965 a) about 60 species of vascular plants are represented in Tåkern.

In 1842—1844 the water level of Tåkern was permanently lowered 1.7 m and the environmental conditions became very favourable for macrophyte vegetation. Large reed-beds were developed, especially off the western shore, and at the beginning of the twentieth century nearly the whole bottom area was covered by meadows of charophytes. During one period *Elodea canadensis* dominated in eastern Tåkern, but later on the mentioned elodeids disappeared and for some years *Myriophyllum spicatum* became the dominating species. For the present most of the bottom area of the open lake is without elodeid vegetation. However, the hyperhydate vegetation, in which *Phragmites communis* is the dominating species, is gradually expanding lakewards.

Climatic conditions are shown in Figs. 5—6 and 92.

Biotope 32

A. Environment

Situation (Fig. 87). To the east and ca. 100 m from the end of the peninsula Holmsön. Figs. 13—14 in Plates 3—4 in MELIN 1928 are taken from about the same point as Fig. 93 in this paper.

Physiographic survey (Fig. 93). The biotope is representative of the vast reed-bed covering the southwestern part of the lake. Between the low minerogenic peninsula and the reed-bed there was a 2—5 m broad border of water, during the vegetation period often totally covered with *Ricciocarpus natans*. Other frequently occurring plant species were *Butomus umbellatus*, *Carex pseudocyperus*, *Cicuta virosa*, *Hottonia palustris*, *Hydrocharis morsus-ranae*, *Lemna minor*, *L. trisulca*, *Oenanthe aquatica*, *Polygonum amphibium*, *Ranunculus sceleratus*, *Sparganium erectum*, and *Spirodela polyrrhiza*.

The biotope, situated 6 m from the outer margin of the open littoral water border, was somewhat sheltered against westerly winds. Wave action was never noticeable. With the exception of occasionally appearing spiroidelids and single individuals of *Hydrocharis morsus-ranae* the *Phragmites* stand was quite pure.

The dry *Phragmites* stems remained for at least one vegetation period.



Fig. 93. Biotope 32 Tåkern.
— Photo S. Björk 620920.

The water (Table 36). On observation occasions in July—Sept. the water depth varied from 0 to 60 cm. In connection with the water level fluctuations the quality of the surface water was subject to great variations. Thus, in July 1962, at a water depth of 30 cm, the specific conductivity was 280 μ S and the pH 7.3, but in Sept. the same year, when the water depth after a rainy period had increased to 60 cm, the conductivity increased to 680 μ S and the pH decreased to 6.6. On that occasion the colour was 240 and the Cl content 590 μ mol/l. In Aug. 1963, at a water depth of 15 cm, the conductivity had again decreased, viz. to 250, the pH was 6.9, the colour 160 and the Cl content 185.

The bottom (Fig. 94). The surface was covered by 5 cm coarse *Phragmites* detritus.

Stratigraphy:

- 0—15 cm Dark brown, loose gyttja with coarse detritus of *Phragmites*.
- 15—23 cm Brown, coarse denser gyttja.
- 23—28 cm Transition layer with gyttja of finer structure than the overlying. The colour varied from brown to grey and grey green.

28—98 cm Grey to grey green clay with gyttja (in the upper part) to clay gyttja and clayey gyttja. In the lowermost part with algal gyttja consistency.

The pH values increased and the amount of extractable metallic cations decreased downwards. The amounts of extractable elements were approximately the same throughout the analysed core. The content of Ca was, however, somewhat smaller at the two lower sampled levels than at the two upper.

B. *Phragmites communis*

Rhizomes and roots (Fig. 94). Most of the horizontal rhizomes occurred between 20 and 60 cm. A few thick roots from the horizontal rhizomes were noted at 80 cm and fine roots occurred down to 98 cm. A dense felt of fine roots was developed down to 20 cm. One to three of the basal nodes of some shoots had fine roots. (Dead *Equisetum* rhizomes and roots occurred down to 85 cm.)

Shoot density. The mean of available records was 60.

Flowering time. As a rule the

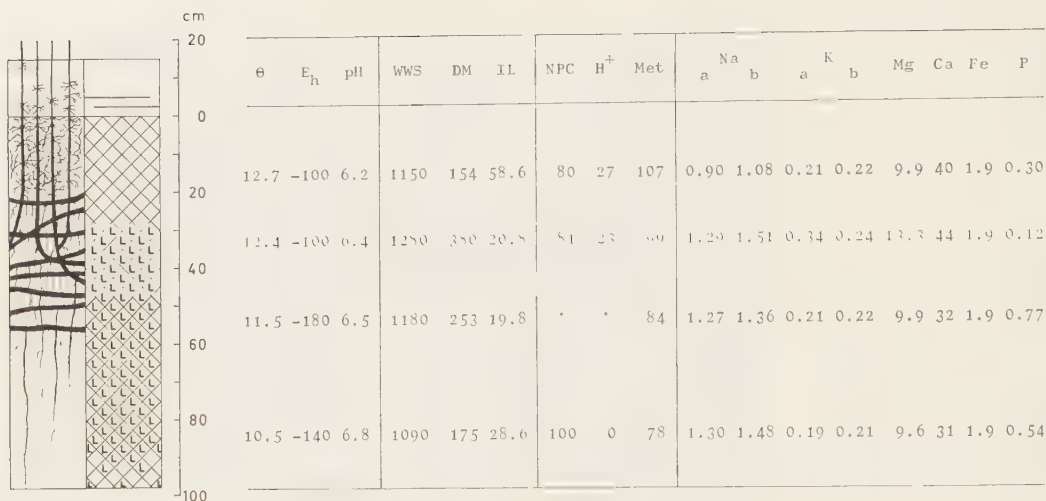


Fig. 94. Biotope 32 Tåkern 630823. Vertical section and soil analyses.

panicles were in full flower in the third or fourth week in Aug.

Panicle frequency. The mean of available records was 75 ‰.

Further data in Tables 37—39, 41—44.

Lake Western Ringsjön

With Biotopes 33—34

General Description

55°53'N, 13°29'E. Altitude 54 m a.s.l. Area 14.5 km². Max. depth 6 m.

Lake Ringsjön consists of the three basins Sätöftasjön, Eastern and Western Ringsjön, which from a limnologic point of view have different characters.

The southwestern part of Western Ringsjön is surrounded by Silurian shales, the northeastern part by a narrow area of Jurassic sandstone to the north followed by the large gneiss area of Southwestern Sweden. The shales have a very favourable influence on the fertility of the soil, but the sandstone has only to some degree a favourable influence. The soils northeast of the lake are slightly clayey Archaean moraine and to the southwest there is moraine clay. The super-

ficial layer is designated clayey moraine sand. The shores are minerogenic throughout.

The geologic conditions are reflected in the distribution of forests (mostly of beech and oak, in SW 0—10 ‰, in NE 10—20 ‰ of the total land area) and arable land area (in SW 75 ‰, in NE 30 ‰).

As for climatic conditions see Figs. 5—6 and 95.

In 1883 the water level was permanently lowered 1.5 m and is now regulated (Fig. 95).

The mean of monthly transparency measurements from May to Oct. 1947 was 330 cm (max. 480 in May, min. 210 in Sept.) in the eastern part of Western Ringsjön (ANDERSSON 1948). LUNDH (1951 a) gives the mean 320 cm for more than 30 determinations made monthly in 1947—1950 in the western part. From 1947—1948 (three water samples) ALMESTRAND (1951) gives the following water analyses: Col 17—22, Sp. cond. 210—220 μS, K 80—100, Mg 100, Ca 780—900, Cl 370—390, SO₄ 180—390, HCO₃ 1.510—1.900 μmol/l. In June 1965 and Aug. 1966 the present author obtained the following data (pelagic superficial water): Tr > 350/200, Col 10/15, Sp. cond. 250/250 μS, pH 8.5/8.1, Na 380/340, K 71/74, Mg 160/170, Ca 1100/1020, Cl 470/435, and Fe 0.7/ · μmol/l. The conductivity has increased with ca. 25 ‰ during the last 15 years (ALMESTRAND 1965).

Investigations of the phytoplankton were

carried out by ANDERSSON (1948) and LUNDH (1951 c), who also studied epiphytic diatoms and macroscopic algae.

The macrophyte vegetation is described by LUNDH (1951 a, 1951 b). In spite of the lowering of the water level the hyperhydate vegetation, from a quantitative point of view, is not yet especially prominent (cf. also TRYBOM 1893). *Phragmites communis* is the most common species. The ephydate vegetation is insignificant, while the elodeid vegetation is very well developed and represented by *Ceratophyllum demersum*, *Elodea canadensis*, *Myriophyllum* and *Potamogeton* spp.

Biotopes 33—34

A. Environment

Situation (Fig. 87). The biotopes were situated close to each other immediately south of the inlet from Eastern Ringsjön. Biotope 33 was located ca. 3 m before and biotope 34 ca. 3 m behind the measuring stick in Fig. 96.

Physiographic survey (Fig. 96). As is seen in Fig. 96 two very different clones, one with short and one with tall shoots, were growing in well-delimited stands which bordered on each other. The boundary between them was winding but always sharp, and there was hardly any intermingling from one clone to the other. In the sampling area the border line ran parallel to the shore line, but to the north it was perpendicular to the shore. Thus both clones were represented in all occurring water depths within this shore reach. In fact the tall clone was almost surrounded by the small one with the exception of the lakeward side.

Along the shore there was a girdle of *Salix* and *Alnus* bushes and above this scattered trees of *Alnus*, *Pinus*, and *Betula*. Summer houses have been built here and there. Both biotopes were sheltered against winds from all directions except northwest. No wave action was noticeable during the vegetation period.

In some years the dry *Phragmites* stems remained for the next vegetation period.

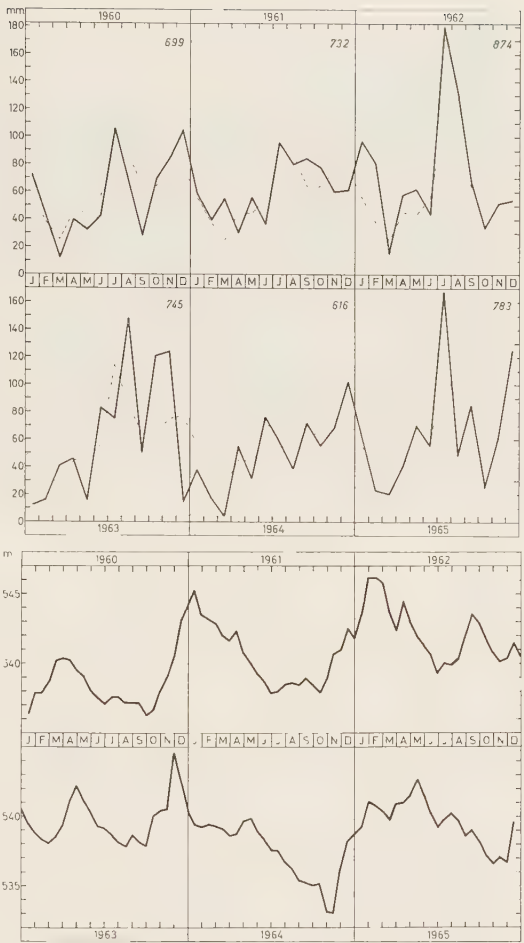


Fig. 95. Top: Precipitation per month (solid line) and monthly mean precipitation for the period 1960—1965 (broken line) in Stehag (at W. Ringsjön). Bottom: Water level fluctuations in W. Ringsjön. The heights given in m a.s.l.

Biotope 33

Physiographic notes (Fig. 96). The dense *Phragmites* stand of relatively short shoots was pure with the exception of *Lemna minor*, *L. trisulca*, *Spirodela polyrrhiza*, and *Ceratophyllum demersum*. Due to, among other things, the water depth conditions, the frequency of these species was variable. Periodically, during periods with high water, they were frequent. Thus the water surface was sometimes nearly totally covered by the spirodelids. In other periods their occurrence was very sparse.



Fig. 96. Biotopes 33—34 W. Ringsjön. Biotope 33 situated ca. 3 m before and biotope 34 ca. 3 m behind the measuring stick. — Photo S. Björk 620904.

The water (Table 36). The surface water quality changed with the water depth. During periods with high water the exchange between the open lake and the biotope was so lively that the quality in the biotope greatly resembled that in the lake, while during periods with decreasing depth, great differences gradually appeared. Low water level was accompanied by a marked fall in the ionic concentration, especially when there was a quantitatively rich development of *spirodelids* and *elodeids*. In Table 36 these conditions are exemplified by data from two sampling occasions, viz., July 18, 1963, when the quantitatively development of *Lemna*, *Spirodela*, and *Ceratophyllum* was weak, and June 25, 1964, when the quantitative development of these plants was very high. On the other hand, the late summer and autumn of 1962 were characterized by fairly high water level. In the beginning of Sept. (water depth 60 cm) the specific conductivity was 250 μ S, the pH 7.4, and the Cl concentration 470 μ mol/l. At the beginning of Oct. (depth

70 cm) the corresponding values were 260, 7.1, and 530.

Interstitial water was sampled in dug pits as well as obtained by suction of fresh soil samples. The bottom consists of a superficial gyttja layer and beneath this sand (cf. below). When the gyttja layer was perforated there was an upwelling of water which was easily seen during low water conditions. Thus the quality of the superficially sampled interstitial water was largely due to the level from which the soil samples for suction were taken as well as to the depth of the pit in which water was sampled.

The interstitial water from the sand was, compared with that from the pure gyttja, characterized by having considerably higher specific conductivity and pH, higher concentrations of Na, Mg, and Ca, and higher alkalinity. The increase in the K content was fairly small and the Cl concentration decreased.

The bottom (Fig. 97).

Stratigraphy:

0— 30 cm Brown, loose, coarse gyttja.

- 30—37 cm Grey beige stony, gravelly sand, somewhat intermingled with organic matter. Dead rhizomes and roots of *Equisetum*.
- 37—100 cm Grey stony and gravelly sand, downwards of lighter colour, less content of stones and gravel, more fine sand and with increasing amount of ocularly visible CaCO_3 grains. Blackish layer between 43 and 44 cm.

The gyttja as well as the minerogenic soil at the two upper sampled levels — which represent the surface layer of an old washed minerogenic bottom — had a low content of extractable metallic cations. Due to the occurrence of CaCO_3 the amount increased downwards and so did the percentage of neutralization. As for the extractable amounts of Na, K, and Fe, there was a minimum in the upper minerogenic soils. The content of extractable Mg was low in the upper layers.

B. *Phragmites communis*

Rhizomes and roots (Fig. 97). The main part of the rhizomes and root system was concentrated to the organogenic soil. Horizontal rhizomes occurred from 20 to 50 cm, but the frequency was low in the minerogenic soil. Thick roots occurred down to at least 65 cm and fine roots were found at 75 cm. Especially the upper 20 cm of the gyttja were densely interwoven by fine roots from the vertical rhizomes. One to five basal stem nodes were richly provided with fine roots.

Shoot density. Ca. 110. In 1962—1963 densities from 90 to 130 were recorded.

Flowering time. This was dependent on, among other things, the water level conditions. The panicles

came into full flower at some time between the third week in Aug. and the second week in Sept.

Panicle frequency. In 1962 25 % (panicles partially or totally sterile); in 1963 70 % (panicles fertile and well developed).

Further data in Tables 37—39, 42—45.

Biotope 34

Physiographic notes (Fig. 96). Though the *Phragmites* leaf area per bottom area was greater in biotope 34 than in 33, there was, due to the lesser shoot density and the considerably higher shoots, better light conditions at the water surface in 34 than in 33. The highest quantitative development of spirodelids and elodeids was also always found in biotope 34. The water surface was often totally covered by *Lemna minor* and *Spirodela*. At other times the water was filled with *Ceratophyllum demersum* and *Lemna trisulca* was frequent. Single individuals of *Elodea canadensis* and *Sium latifolium* were also noted.

The water (Table 36). The depth was about 20 cm greater in biotope 34 than in 33. In spite of the small distance between the biotopes, there were sometimes considerable differences — most evident at low water level — with respect to the concentrations of the analysed elements. At high water level there were no or only small differences.

Analyses of interstitial water sampled in a dug pit are given in Table 36. However, the pit in this case was dug through the whole gyttja layer and the water thus became a mixture of interstitial water from the organogenic and the underlying minerogenic soil.

The analyses of interstitial water obtained through suction give a better idea about the differences in the quality in the different soils. The water in the sand

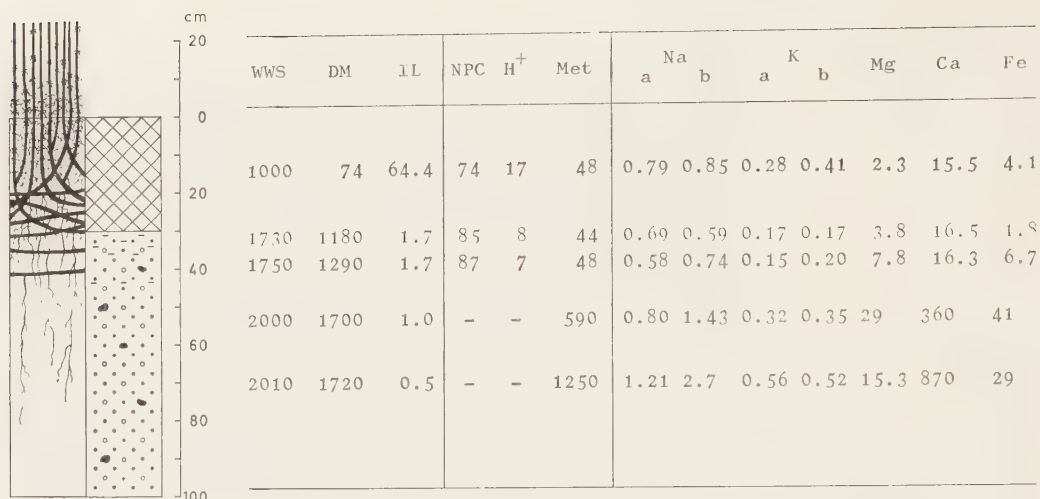


Fig. 97. Biotope 33 W. Ringsjön 640806. Vertical section and soil analyses.

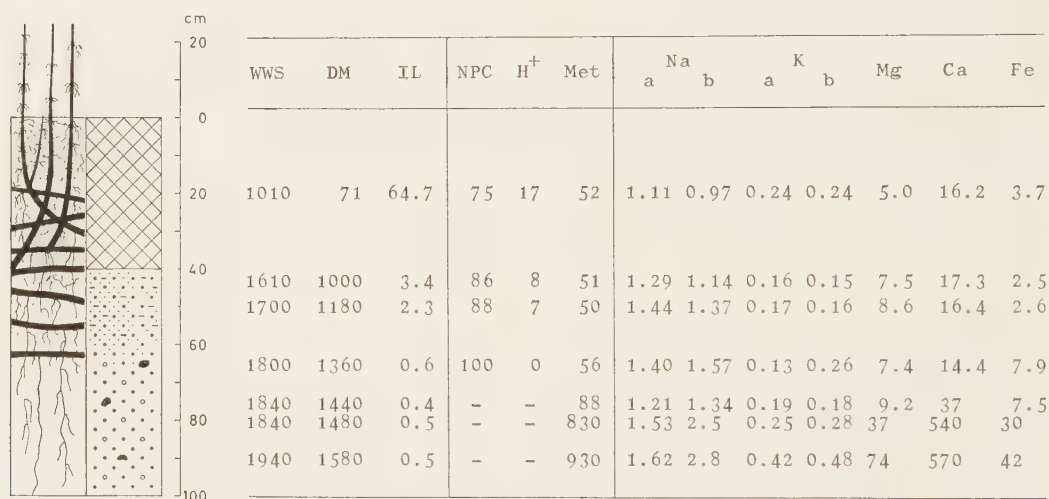


Fig. 98. Biotope 34 W. Ringsjön 640806. Vertical section and soil analyses.

was characterized by having a higher specific conductivity and Ca concentration than the water of the overlying gyttja. At the lower sampled level there was also, compared with the gyttja, a considerable rise in the alkalinity and in the Na, K, Mg, and also in the Cl content.

The bottom (Fig. 98).

Stratigraphy:

0—40 cm Brown, loose coarse gyttja.

40—60 cm Grey-beige sand with organic matter (rich in dead *Equisetum* rhizomes and roots).

60—100 cm Grey stony and gravelly sand. Downwards with increasing amount of ocularly visible CaCO₃ grains.

In the gyttja and the upper part of the minerogenic soil layer, representing a washed old bottom surface, the amounts of extractable metallic cations were small. In the lower part of the

section there was a sudden increase in the amount of extractable metallic cations, which was due to the presence of CaCO_3 grains, ocularly easily visible. The percentage of neutralization increased downwards.

Broadly speaking, the conditions in this section correspond to those described from biotope 33. In comparison with biotope 33 the conditions in the biotope 34 section are, however, somewhat more extended. Probing along the boundary between the clones have indicated that no differences with respect to the stratigraphic conditions existed between the two sides of the clone limit. The analytical data on soil and interstitial water from the two clones represent sites within the biotopes sampled at random to illustrate the bottom conditions. If they had been situated at the same distance from the shore line, on both sides of the clone limit where this runs perpendicular to the shore, still more similar data would probably have been obtained.

B. *Phragmites communis*

Rhizomes and roots (Fig. 98). The main part of the rhizome and root system was found in the gyttja. However, horizontal rhizomes occurred, though with low frequency, in the minerogenic soil down to 65 cm. Rather many thick roots occurred down to 90 cm and fine roots were found throughout the section. In the gyttja layer a dense, fine root felt was developed. One to four of the basal nodes were provided with fine roots.

Shoot density. Ca. 45.

Flowering time. Dependent on weather and water level conditions the

flowering took place at some time during Sept., mostly during the latter half of the month.

Panicle frequency. In 1962 40 %, in 1963 80 %.

Further data in Tables 37—39, 42—45.

Lake Krankesjön

With Biotopes 35—36

General Description

55°42'N, 13°29'E. Altitude 19 m a.s.l. Area 4.2 km². Max. depth 2 m.

By WENNBERG (1949) Krankesjön is considered to be a kettle lake. The Cretaceous bedrock has a very favourable influence on the fertility of the soil, which, however, consists of sand and, in some places, stony gravel. Fen areas are found, especially to the west of the lake. The arable land area has been ca. 50 %. Some smaller *Pine* and broad-leaved forests occur.

The water level was permanently lowered in 1892 and since the 1940's a further lowering has taken place (LUNDH 1951 b).

The mean of 8 transparency measurements in July—Sept. 1944—1949 (LUNDH op.c.) was 60 cm (min. 30, max. 80 cm). From the years 1946—1948 (5 sampling stations, 23 water samples) ALMESTRAND (1951) gives the following analytical data on the water from the superficial layer: Col 22—50, Sp. cond. 280—410, m=340 μS , pH 7.7—8.6, K 74—150, m=110, Mg 160—330, m=230, Ca 1400—1950, m=1700, Cl 450—590, m=540, SO_4 310—850, m=500, and HCO_3 2280—3150, m=2610 $\mu\text{mol/l}$. It is evident from the analyses given by ALMESTRAND (op.c.) that the quality of the water is subject to considerable variations. See also the data given in Table 36.

The phytoplankton, epiphytic diatoms, macroscopic algae, and macrophyte vegetation were investigated by LUNDH (1951 b, 1951 c). After the lowering of the water level a vigorous development of the hyperhydate vegetation took place as bottom areas with organogenic sediments became accessible.



Fig. 99. Biotope 35 Kranke-sjön. — Photo S. Björk 660817.

Large areas in the western and southeastern Krankesjön are overgrown by *Phragmites communis*, the most frequent hyperhydric species. Plaur formations (mostly aground) with well-developed parafluvial occur. In the elodeid vegetation there has been great variations, resembling those observed in Lake Tåkern (cf. LUNDH 1951 b).

Biotope 35

A. Environment

Situation (Fig. 87). At the northern part of the eastern shore, in the middle zone of the reed-bed.

Physiographic survey (Fig. 99). Above the shore line is low and plane, sandy ground, overgrown with grasses and sedges. The biotope was exposed to winds from all directions. During the vegetation period the wave action was weak.

The *Phragmites* stand was nearly quite pure, only single individuals of *Cicuta virosa*, *Lemna minor*, *Ricciocarpus natans*, and *Typha angustifolia* were noted from the biotope. In the landward zone of the reed-bed *Carex acuta* and *Solanum dulcamara* and in the lakeward zone *Elodea canadensis*, *Potamogeton perfoliatus*, and *Utricularia vulgaris* were found.

The dry *Phragmites* stems were, as a rule, broken in the spring.

The water (Table 36). Cf. biotope 36, p. 146.

The bottom (Fig. 100).

Stratigraphy:

- 0— 5 cm Sand with black organic matter, CaCO_3 grains and small fragments of mollusk shells.
- 5— 20 cm At the top light grey, downwards darker sand.
- 20— 36 cm Dark grey-brown, strongly sandy drift gyttja.
- 36— 60 cm Sand with alternating darker grey-black and lighter grey layers dependent on the amount of organic matter. In the upper part brownish due to iron.
- 60—130 cm Light grey, homogeneous sand, rich in CaCO_3 grains. At 60 cm a sharp upper limit for the calcareous sand.

Without doubt the sandy, somewhat humic soil layer below 36 cm represents an old bottom surface layer, which during a period of higher water level was covered by the drift gyttja (20—36 cm). This was later on covered by (still calcareous) sand, probably in connection with the recent lowering of the lake.

The high CaCO_3 content of the sand

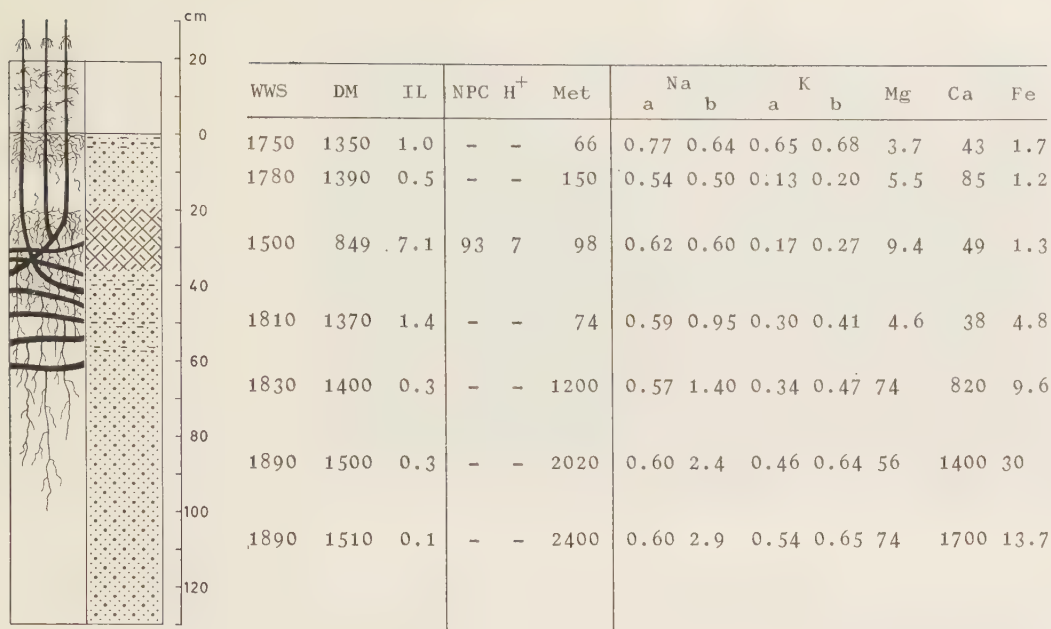


Fig. 100. Biotope 35 Krankesjön 640902. Vertical section and soil analyses.

characterized the soil section. The drift gyttja layer is the only analysed one in which it was possible to estimate the percentage of neutralization. In comparison with the conditions in the downwards increasingly more and more calcareous sand below 60 cm, the extractable amounts of metallic cations were rather small above this limit.

B. *Phragmites communis*

Rhizomes and roots (Fig. 100). Most of the horizontal rhizomes occurred between 30 and 60 cm. Only single horizontal rhizomes were found in the calcareous sand below 60 cm. The thick roots (diameter ca. 7 mm) occurred down to ca. 100 cm. The lowest level for fine roots was 90 cm. The frequency of fine roots was high down to 10 cm and from 20 to 45 cm, but between these layers the frequency was noticeably low. The fine roots penetrating the sandy soil

were characteristically undulated. Up to ca. 25 cm the shoot nodes were richly provided with fine roots.

Shoot density. Ca. 25.

Flowering time. The panicles usually began to flower as early as in the middle of Aug. already before they were fully grown out.

Panicle frequency. Ca. 85 %.

Further data in Tables 37—39, 42—44.

Biotope 36

A. Environment

Situation (Fig. 87). Lakewards from the continuous reed-bed in southeastern Krankesjön an archipelago of scattered hyperhydate stands occurs, partly of plaur character. The biotope was situated 5 m inside the margin of the continuous reed-bed extending from the shore.

Physiographic survey (Fig. 101). The outermost margin of the reed-bed was floating. In the biotope the rhizomes and roots were, however, anchored in the loose



Fig. 101. Biotope 36 Kran-
kesjön. — Photo S. Björk
640807.

gyttja. At high water level the stand was somewhat lifted and partly floating, but the bottom surface submerged. The reed-bed was split into smaller or larger, dense, semi-floating stands, separated by narrow grooves with bare loose gyttja. A rise in the water level would cause an extensive plaur formation.

The margin of the reed-bed was provided with a well-developed parafyllion (THUNMARK 1952, p. 107). The following plant species were noted from the marginal zone: *Bidens tripartita*, *Carex pseudocyperus*, *Cicuta virosa*, *Galium palustre*, *Glyceria maxima*, *Epilobium hirsutum*, *Lysimachia thyrsiflora*, *Myosotis palustris*, *Rumex hydro-lapathum*, *Scutellaria galericulata*, *Solanum dulcamara*, *Typha angustifolia*, *Veronica anagallis-aquatica*. In the biotope the *Phragmites* stand was quite pure.

The biotope was exposed to winds from all directions. No wave action was noticeable in it.

The dry *Phragmites* stems remained for at least one vegetation period.

The water (Table 36). Surface water samples were taken in the groove surrounding the sampled stand. As the exchange of water between the open lake and the groove was fairly lively at summer normal water level, the quality of the water here did not differ much from that found in biotope 35 at the

corresponding times. A lowering of the water level during the autumn in 1964 was followed by a rise in the specific conductivity, the alkalinity and the calcium content of the water in biotope 36. No such changes were noted in biotope 35 (openly exposed to the lake).

Interstitial water was obtained by suction of fresh soil samples from 25—35 and 68—78 cm. In comparison with the surface water the interstitial water was characterized by having considerably higher specific conductivity, Mg, Ca, and Fe content. The concentration of Na and Cl was only slightly higher, while the K concentration was lower than in the surface water.

The bottom (Fig. 102).

Stratigraphy:

- | | |
|--------------|---|
| 0—ca. 20 cm | Black, fairly solid gyttja, rich in coarse <i>Phragmites</i> detritus. Shells of microdimensional freshwater mussels. |
| ca. 20—65 cm | Very loose gyttja. Down to 45 cm the colour was black, below it was browner. Mollusk shell frag- |

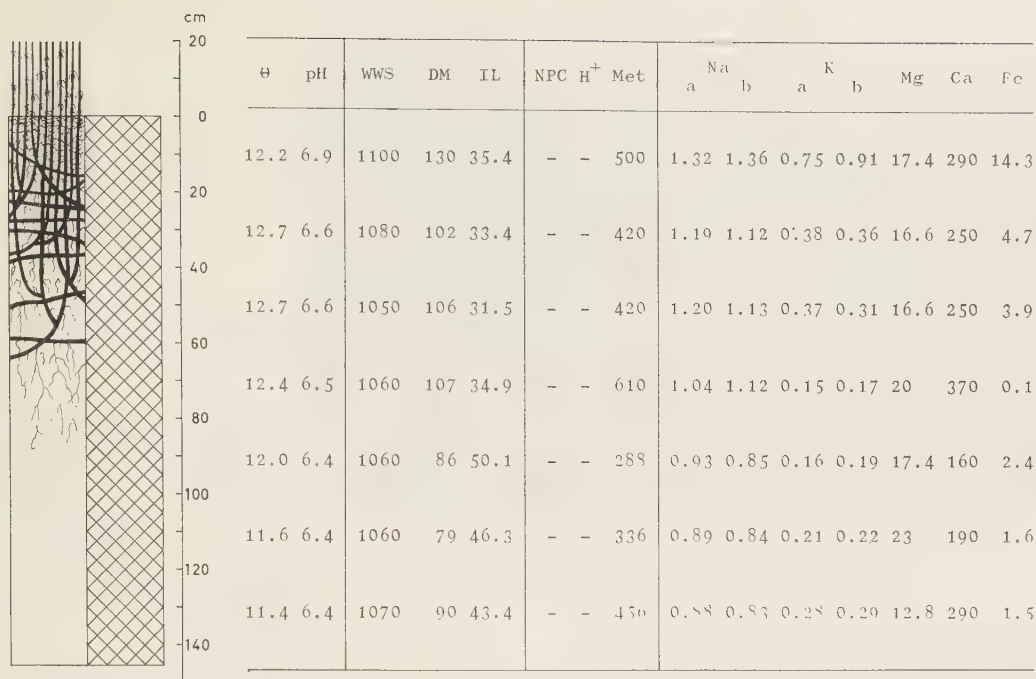


Fig. 102. Biotope 46 Krankesjön 640918. Vertical section and soil analyses.

ments and, in the upper part, some *Phragmites detritus*.

65—100 cm Distinctly brown gyttja. In the upper part with shall fragments and opercula. In the lower part the gyttja was somewhat elastic and of algal gyttja appearance.

100—146 cm Light brown, elastic gyttja of algal gyttja appearance. Though no CaCO_3 particles were detectable, there was an evident gas development when it was treated with HAc.

The presence of CaCO_3 (mollusk shells and possibly CaCO_3 precipitated by algae) throughout the section caused a definite negative pH displacement in the AmAc extracts from all levels. Gradually lower pH values were obtained in

a downward direction. When the pH was measured in the suctioned interstitial water, considerably higher values were, as usual, obtained. However, also in the two interstitial water samples there was a tendency to a downward decrease in pH.

The variations in the Ca content of the gyttja were decisive of the amounts of extractable metallic cations at the different levels. The distribution of extractable Na, K, and Mg was fairly even throughout the section. There was, however, with respect to Na a trend of downwardly decreasing amounts. In the superficial black gyttja the amount of extractable Na, K, and Fe was definitely higher than in the rest of the section.

B. *Phragmites communis*

Rhizomes and roots (Fig. 102). The vertical rhizomes, some of them



Fig. 103. Lake Björkesåkrasjön. The reed-bed margin outside biotope 37. — Photo S. Björk 640827.

60—70 cm, were richly provided with fine roots. The layer of horizontal rhizomes (highest frequency between 20 and 60 cm) was rather sparse. The frequency of thick roots was low, and these as well as the thin roots were slender. Thin roots were found down to 90 cm. One to three shoot nodes were provided with fine roots.

Shoot density. On the split up semi-plaur formations the shoot density was as high as ca. 140.

Flowering time. In the second to third week in Sept.

Panicle frequency. Ca. 80 %.

Further data in Tables 37—39, 42—44.

Lake Björkesåkrasjön

With Biotope 37

General Description

55°32'N, 13°24'E. Altitude 60 m a.s.l. Area 1.1 km². Max. depth 2 m.

Björkesåkrasjön is a moraine lake. The Cretaceous bedrock, which has a favourable influence on the soil fertility, is covered with moraine clay. The cultivated surface soil layer is designated clayey moraine sand. The

arable land area comprises ca. 60 % of the total land area and the forests (beech and planted spruce) 10 to 40 %.

The water level of Björkesåkrasjön was permanently lowered in 1892. The following analyses of 4 water samples taken from the superficial layer in 1947 are given by ALMESTRAND (1951): Col 50—80, m=63, Sp. cond. 240—250, m=250 μ S, pH 8.2—8.8, K 84—100, m=95, Mg 185, Ca 1100—1550, m=1320, Cl 540—700, m=590, SO₄ 160—180, m=170, HCO₃ 2300—2440, m=2380 μ mol/l. In Sept. 1955 the present author obtained the following data (sampling in an opening in the *Myriophyllum* meadow centrally in the lake): Col 50, Sp. cond. 240 μ S, pH 9.2, Cl 640 μ mol/l, (O₂)s 148 %.

Investigations of phytoplankton, epiphytic diatoms, macroscopic algae, and macrophyte vegetation are presented by LUNDH (1951 b, 1951 c).

To a large extent the lake is surrounded by fens and bordered by broad reed-beds of *Phragmites communis* and *Typha angustifolia*, the outer margins of which are developed as plaur. In some years practically the whole bottom was overgrown by elodeids reaching the water surface, above all by *Myriophyllum spicatum*, *Potamogeton pectinatus*, and charophytes, especially *Chara aspera*. Besides the macrophyte species reported by LUNDH (1951 b) the following may be mentioned: *Lemna trisulca*, *Riccia fluitans*, *Ricciocarpus natans*, *Spirodela polyrrhiza*.

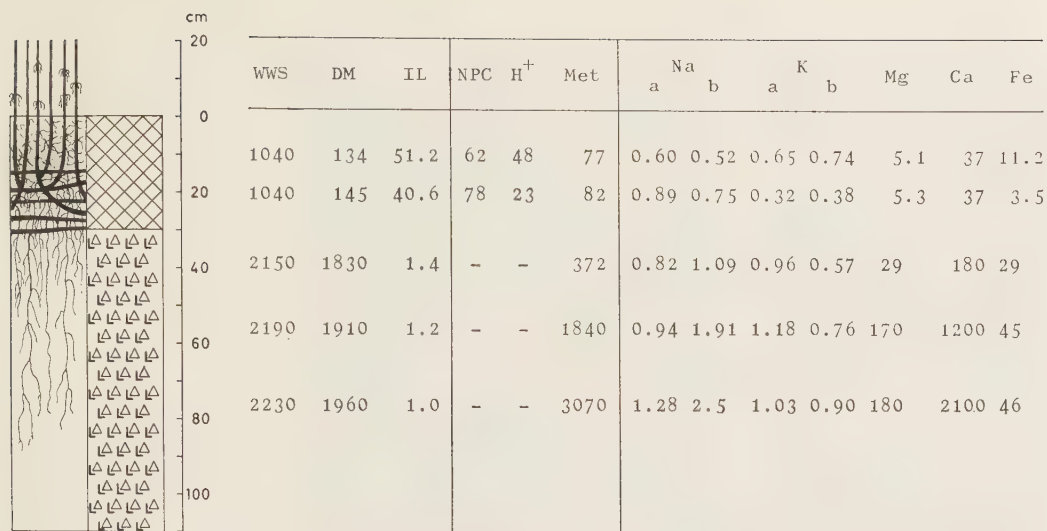


Fig. 104. Biotope 37 Björkesåkrasjön 640827. Vertical section and soil analyses.

Biotope 37

A. Environment

Situation (Fig. 87). At the middle reach of the northeastern shore, southwest of Hjortelöpet.

Physiographic survey (Fig. 103). Above the shore there are meadows and groves of broad-leaved trees. For the rest the ground is cultivated.

The biotope was exposed to westerly winds. No wave action was noticeable there.

In the landward zone of the vegetation belt the *Phragmites* reed-bed was to a large degree intermingled with other plant species. During the observation period 1955—1966 a decrease in the quantitative development of *Phragmites* was clearly noticed in this zone. The decrease with respect to *Phragmites* was accompanied by an increase in the quantity of intermingling species as *Iris pseudacorus*, *Lysimachia thyrsiflora*, *Sium latifolium*, and *Sparganium erectum*. In the lakeward zone of the reed-bed, where the biotope was situated, the *Phragmites* stand was until 1965 nearly pure. The following species, most of which represented by single shoots and individuals, were noted: *Alisma plantago-aquatica*, *Carex pseudocyperus*, *C. rostrata*, *Equisetum fluviatile*, *Hottonia palustris*, *Hydrocharis morsus-ranae*, *Iris pseudacorus*,

Lemna minor, *L. trisulca*, *Mentha aquatica*, *Riccia fluitans*, *Rumex hydrolapathum*, *Sium latifolium*, *Sparganium erectum*, *Spirodela polyrrhiza*, *Stratiotes aloides*, *Typha angustifolia*, and *T. latifolia*. The spirodelids and riccids were most frequent.

The dry *Phragmites* stems sometimes remained unbroken for the following vegetation period.

The water (Table 36). In Aug. 1962 the surface water (depth 45 cm) had a specific conductivity of 340 μ S and a pH value of 7.9. In Aug. 1964, when the biotope was emerged, the conductivity of the surface water in the margin of the reed-bed (depth 10 cm, distance from the biotope 9 m) was 220 μ S and the pH 9.1 (bright sun, water temp. 24.9°C). At the same time as the latter sample was taken, interstitial water was sampled in the biotope in a 42 cm deep pit. This water derived partly from the superficial organogenic soil layer and partly from the uppermost part of the underlying minerogenic soil. Compared with the quality of the simultaneously sampled surface water, the interstitial

water was characterized by having decidedly higher specific conductivity, alkalinity, Mg, Ca, and Fe content. The concentrations of Na as well as of K and above all of Cl were, however, lower. Probably, the low K and Cl concentrations in the interstitial water were, at least partly, due to the uptake by *Phragmites*.

The bottom (Fig. 104).

Stratigraphy:

- 0—30 cm Dark brown, dense gyttja.
- 30—110 cm Hard moraine clay, somewhat washed in the uppermost part. Rich in CaCO_3 grains. Dead *Equisetum* rhizomes and roots common in the upper part.

The bottom was emerged when the described core was obtained. For this reason there may have been changes in the superficial gyttja layer, which were responsible for the noticeably low percentage of neutralization. In the moraine clay there was a downward increase in the content of extractable Ca. The amount of extractable K was fairly low throughout, while there was a high and downwardly increasing content of extractable Fe in the clay.

B. *Phragmites communis*

Rhizomes and roots (Fig. 104). The highest frequency of horizontal rhizomes occurred between 20 and 30 cm. Only a few living horizontal rhizomes were observed in the minerogenic soil. Living thick roots were found down to 80 cm, and also fine roots occurred at this level. The highest frequency of fine roots was found in the lower half of the gyttja layer. One to two of the basal shoot nodes were often provided with fine roots.

Shoot density. Ca. 50.

Flowering time. In the second to third week in Sept.

Panicle frequency. Ca. 70 %.

Further data in Tables 37—39, 41—44.

Lake Tystrup Sö

With Biotopes 38—39

General Description

55°21'N, 11°35'E. Altitude 7 m a.s.l. Area 6.6 km². Max. depth 21 m.

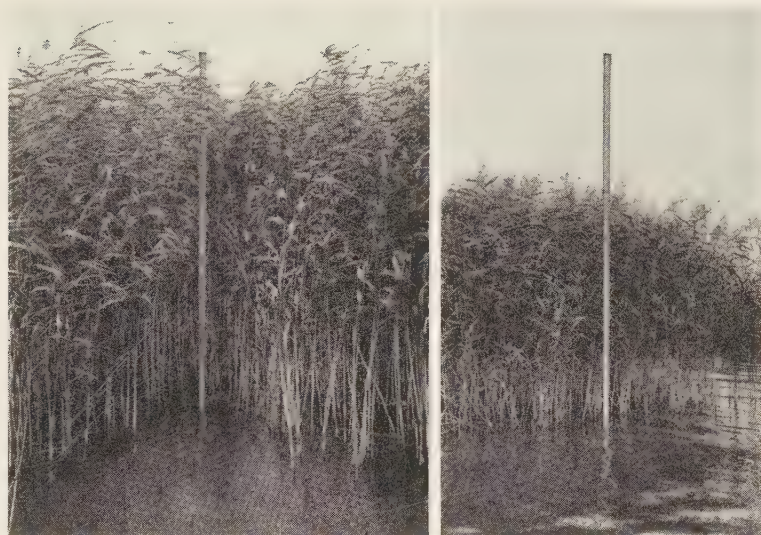
The lake, which belongs to the water-course system of the river Suså consists of a northern and a southern basin. The bedrock of Tertiary clays is covered by calcareous moraine clay. Surveys of the geologic and other physiographic conditions of the Tystrup Sö area are given by ANDERSEN (1924, 1931), BERG (1943), and HANSEN (1950), who also studied the bottom deposits of the lake.

Along parts of the eastern shore as well as along part of the southern shore there are beech forests. For the rest the area around the lake is arable land. In the main the shores are minerogenic.

Water analyses from Suså upstream and downstream from the lake are given by BERG (op.c.) and analyses from several stations in the lake by KRISTIANSEN & MATHIESEN (1964) in their study on the phytoplankton. In the summer the water of the superficial layer in the southern basin was found to have about the following characteristics: Tr 170, pH 8.4, Ca 2500 $\mu\text{mol/l}$, Cl 1100 $\mu\text{mol/l}$ and Alk 3800—4000 $\mu\text{eq/l}$. In the northern basin the specific conductivity was around 500 μS .

The lake is almost surrounded by reed-beds, mostly broad and dense, the main part of which are made up by *Phragmites*. For practical purposes investigations of *Phragmites* were carried out by BÖCKER et al. (in BAGGESGAARD RASMUSSEN et al. 1948), who calculated the total reed-bed area in the Tystrup-Bavelse lakes to 25 ha.

Fig. 105. Left: Biotope 38 Tystrup Sö. Right: Biotope 39 Tystrup Sö. Length of measuring stick 1 m. — Photo S. Björk 621009.



Biotopes 38—39

A. Environment

Situation (Fig. 87). Immediately south of the cape protruding west of “Kalvehave” in the southern part of “Naesbyholm Storskov”. The distance between the biotopes was 20 m.

Physiographic survey (Fig. 105). Between the two investigated clones there was a gap in the macrophyte vegetation. Towards this open reach the margins of both clones were sharp, and the shoots were of the same size from the inner parts of the stands right out to their margins.

The shore reach has a northwest-southeast direction and the biotopes were exposed to the southwest. Above the shore line was a 10 m broad, gently sloping zone immediately followed by a very steep, 8 m high, precipice conformous with the shore line. The plane ground above the precipice is cultivated. Tall beeches and oaks grow between the shore and the cultivated ground. Due to this the biotopes were overshadowed in the morning. As the biotopes were openly exposed from the lake they were fairly windy and the outer parts of the *Phragmites* leaves were torn before the flowering period.

Above the shore line was a girdle with luxuriant *Eupatorium cannabinum* and *Phalaris arundinacea*. In the biotopes the *Phrag-*

mites stands were quite pure. During the observation period the dry stems were regularly broken in the spring.

Biotope 38

The water (Table 36). On the observation occasions in Aug. to Oct. in 1962—1964, the water depth varied from 25—55 cm. The exchange of water between the lake and the biotope was lively. The recorded values for the specific conductivity varies from 510 to 580 μ S, for the pH from 7.8 to 8.8, and for the Cl content from 1180 to 1290 μ mol/l.

The bottom (Fig. 106).

Stratigraphy:

- 0— 9 cm Grey-yellow stony sand, rich in mollusk shell fragments. The surface stones (flint stones common) with crusts of CaCO_3 .
- 9—115 cm In the upper part (down to ca. 30 cm) dark brown, dense soil, very rich in highly humified radicels which gave the soil a peat-like (or drift gyttja-like) appearance. Below ca. 30 cm very dense black brown soil rich in radicels and some-

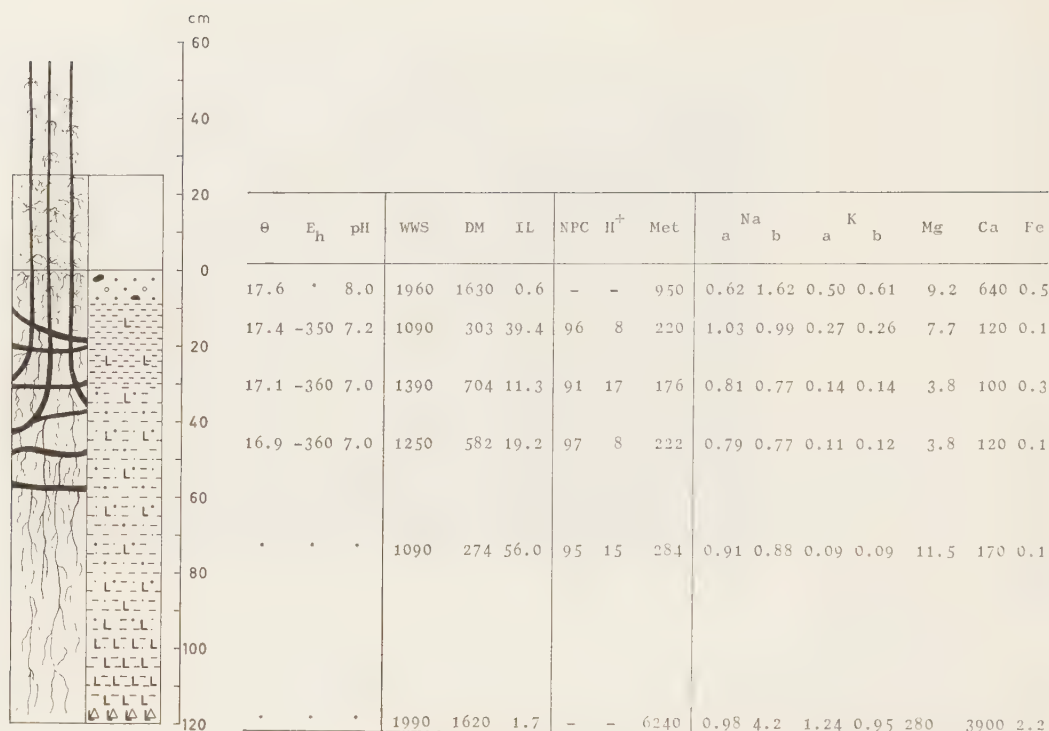


Fig. 106. Biotope 38 Tystrup Sö 630901. Vertical section and soil analyses.

what sandy, downwards with increasing clay content, here and there with clay gyttja appearance. In the lower part rich in wood.

115—120 cm Light grey-blue, calcareous moraine clay. At the transition from organogenic to mine-rogenic soil high frequency of flint stones and pieces of chalk.

The values obtained for extractable metallic cations and percentage of neu-tralization were high throughout the "organogenic" soil layer (i.e., the whole layer coloured by dark organic matter). When dried soil samples from the lower levels of the organogenic layer were treated with HCl there was an evident fizzing.

The content of extractable K was low in the organogenic soil, especially in the

lower part, and also the amounts of extractable Mg and above all Fe were relatively low there.

B. *Phragmites communis*

Rhizomes and roots (Fig. 106). The highest frequency of horizontal rhizomes was found between 20 and 30 cm. Living horizontal rhizomes occurred with certainty down to 60 cm. Pieces of rhizomes were also obtained from ca. 75 cm, but probably they were dead. Thick roots were found down to the calcareous moraine clay and fine roots occurred also in the clay. A well-defined superficial fine root layer was not devel-oped, but fine roots were fairly evenly distributed in the upper half of the organogenic soil layer. Many shoots had node roots up to 50 cm from the bottom.

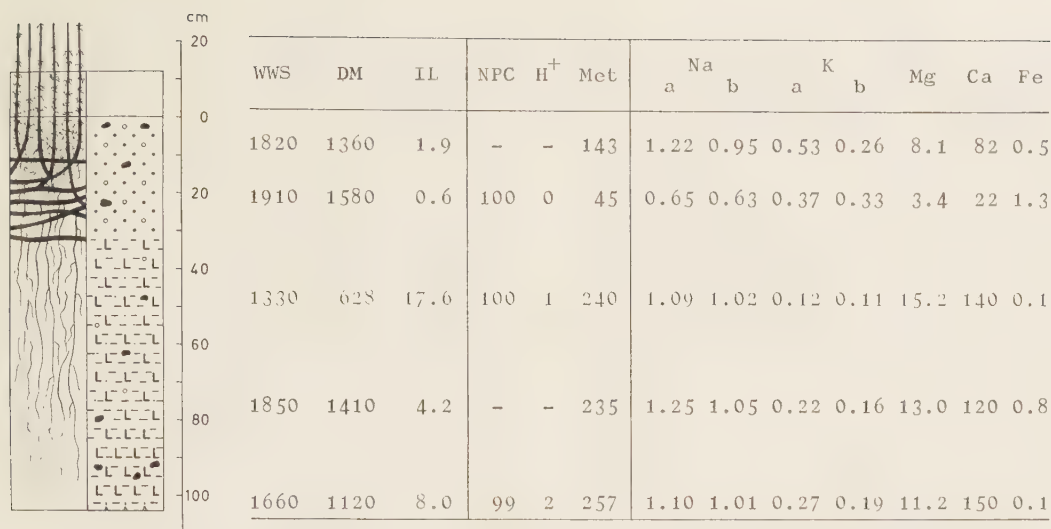


Fig. 107. Biotope 39 Tystrup Sö 640824. Vertical section and soil analyses.

Shoot density. Ca. 35. In 1966 the stand was diminished to ca. 20 % of its former quantity. The remaining shoots were of the same size as before, but the stand was much more sparse. The reason for the retreat is not known, but probably the stand had suffered from damages to the young shoots during the winter 1965—1966. Compare biotope 39.

Flowering time. During the observation period 1962—1964 the panicles were not fully grown out until the middle of Sept. and the flowering took place in the first or second week in Oct.

Panicle frequency. In 1962 ca. 20 %, in 1963 ca. 70 %.

Further data in Tables 37—39, 42—44.

Biotope 39

The water (Table 36). Due to the small distance between the biotopes 38 and 39 as well as to the lively exchange of water between the open lake and the biotopes, the quality of the surface water

with respect to the analysed properties was very much the same in both biotopes.

The bottom (Fig. 107).

Stratigraphy:

- 0— 3 cm Flint stones and pebbles coated with CaCO_3 .
- 3— 32 cm Grey-beige stony and gravelly sand with CaCO_3 grains in the uppermost part.
- 32—103 cm Black clayey soil (in some layers with peaty or drift gyttja appearance), here and there somewhat sandy and gravelly. At 50 cm rich in wood. Stones at 90—95 cm. Below 60 cm very dense and tough. The appearance of the soil at the lower levels like humic clay.
- 103—104 cm In the longest obtained core the lowermost part consisted of grey clayey soil (i.e., probably the limit between the “organo-genic” soil and the moraine clay).

The occurrence of CaCO_3 in the upper part of the superficial layer caused a negative pH displacement in the AmAc

extract. The lower part of the same layer was, however, relatively poor in extractable metallic cations. As in biotope 38 the "organogenic" soil was rich in extractable cations and the percentage of neutralization was high throughout. The amounts of the analytically determined elements were about the same as in biotope 38.

B. *Phragmites communis*

Rhizomes and roots (Fig. 107). The highest frequency of horizontal rhizomes was noted from 10 to 25 cm. The frequency of thick roots was still high at 75 cm and occurred down to the minerogenic soil (the supposed moraine clay). Fine roots were also found throughout the section. A dense fine root layer was developed under the superficial stony horizon. The stem nodes up to 25 cm often had fine roots.

Shoot density. Ca. 70. In 1966 the stand was, from a quantitative point of view, definitely better developed than in earlier years during the observation period, also with respect to the panicles. Compare biotope 38.

Flowering time. The panicles were grown out in the second part of Aug. and came into full flowering during the period second to third week in Sept.

Panicle frequency. In 1962 ca. 55 %, in 1963 ca. 80 %.

Pollen morphology (note). The occurrence of anomalous pollen grains with curious forms was rather common in this clone. The anomalies constituted 2 % of the pollen and consisted of two joined grains, grains with long protuberances etc.

Further data in Tables 37—39, 42—44.

Survey of the Analyses

As the six lakes included here from a geographic point of view are spread over a large area, there are fairly great differences in the climatic conditions between the northern and the southern lakes; there are differences in the amount and chemical composition of the precipitation, in the length of the vegetation period etc.

Furthermore, there are, from a phyto-geographic point of view, differences between the region including biotopes 30—32 and the Scanian-Zealandian region with biotopes 33—39. It is quite possible that the invasion of *Phragmites* has taken place from different regions to the northern and to the southern lakes.

However, all biotopes are situated in lakes within areas which in the literature dealing with the regio-limnologic conditions are definitely characterized as eutrophic.

In the selection of the lakes the aim has been partly to get representative biotopes in different regions and partly to try to get different types of *Phragmites*, if possible growing close together in as similar environment as could be realized in nature in the same lake. Especially in the lakes Western Ringsjön and Tystrup Sö the possibilities of investigating different distinctly separated but closely situated clones were good.

The water level has been lowered in

the lakes with biotopes 30—37. No lake is directly used as recipient of waste water.

A. Environment

In biotopes 36 Krankesjön and 38—39 Tystrup Sö no other macrophyte species than *Phragmites communis* occurred. From the other the following species were noted: *Alisma plantago-aquatica*, *Carex pseudocyperus*, *C. rostrata*, *Ceratophyllum demersum*, *Cicuta virosa*, *Elodea canadensis*, *Equisetum fluviatile*, *Hottonia palustris*, *Hydrocharis morsus-ranae*, *Iris pseudacorus*, *Lemna minor*, *L. trisulca*, *Mentha aquatica*, *Potamogeton obtusifolius*, *Riccia fluitans*, *Ricciocarpus natans*, *Rumex hydrolapathum*, *Sium latifolium*, *Sparanium erectum*, *Spirodela polyrrhiza*, *Stratiotes aloides*, *Typha angustifolia*, *T. latifolia*, and *Utricularia vulgaris*.

The spiroidelids and riccids were most frequent. From a quantitative point of view the intermingling species played a very insignificant rôle.

Probably the water depth did not exceed 50 cm in any of the biotopes 30 and 32—39 at summer normal water level. The greatest water level fluctuations occurred in 33—34 W. Ringsjön (Fig. 95). In the outer part of the horizontal section with biotopes 31 A—D the depth was 1 m.

In biotopes 35 Krankesjön and 38—39 Tystrup Sö there was a good exchange of surface water (analyses in Table 36). The variations in the water quality were here comparatively small. Especially in biotopes 30 Jägern, 32 Tåkern, and 33—34 W. Ringsjön the water exchange during the vegetation period was sometimes poor and great variations

in the surface water quality occurred. There was no subsoil water supply to these biotopes during low water conditions, and the interruption of the surface water exchange implied a gradual lowering of the specific conductivity.

Though the colour of the water was more or less occasionally high in some biotopes during the vegetation period, light in these shallow-water biotopes was probably not a limiting factor in the development of the *Phragmites* shoots in spring.

The lowest specific conductivity, about 90—120 μS , was found in biotope 30 Jägern and the highest, up to 550 μS , in 38—39 Tystrup Sö.

The reaction of the surface water was for the most part decidedly alkaline, but during the vegetation period pH-values lower than 7 have been obtained in 30 Jägern, 32 Tåkern, and 33—34 W. Ringsjön.

From north to south there was an increase in the Na content; from 200—250 $\mu\text{mol/l}$ in Jägern and Tåkern to 300—600 in the Scanian lakes and 1200 in Tystrup Sö.

As for K there was a trend to the same gradient. However, during the vegetation period the concentrations within the dense reed-beds were dependent on the local conditions, including water depth and the intensity of K uptake by the plants (exemplified in 33—34 W. Ringsjön).

The lowest value for Ca, about 300 $\mu\text{mol/l}$, was obtained in 30 Jägern and the highest, about 2000 $\mu\text{mol/l}$, in 38—39 Tystrup Sö. Between these extremes 32 Tåkern and the Scanian biotopes 33—37, some of which varied greatly in Ca content, were grouped.

In 30 Jägern, 33—34 W. Ringsjön and 37 Björkesåkrasjön noticeably low values for Mg were sometimes obtained during the vegetation period.

Also in the case of Cl 30 Jägern and 38—39 Tystrup Sö constituted the extremes. In 30 Jägern, 32 Tåkern and 33—34 W. Ringsjön strong variations have been established.

The quality of interstitial water (Table 36) is exemplified from 33—34 W. Ringsjön (calcareous sand covered with gyttja), 36 Krankesjön (gyttja) and 37 Björkesåkrasjön (calcareous moraine clay).

In W. Ringsjön the specific conductivity of the interstitial water in the overlying gyttja was about one and a half times the average for the surface water, but in the calcareous sand at 85 cm the conductivity was about four times as high. The rise was caused especially by increases in Na, Ca, Cl and in the alkalinity.

In 37 Björkesåkrasjön interstitial water from the calcareous moraine clay had a specific conductivity three times that of the surface water. The rise here was caused by the increase in Ca and alkalinity. The content of Na, K and especially Cl was lower in the interstitial than in the surface water.

In 36 Krankesjön the quality of the interstitial water was about the same at the sampled levels 35 and 80 cm. In comparison with the surface water the specific conductivity was about three times as high. The rise was caused by increased amounts of above all Mg and Ca and an increase in alkalinity. The content of K was only about half that in the surface water.

※

The bottom analyses are exemplified in Figs. 90, 94, 97, 98, 100, 102, 104, 106 and 107.

Due to the stratigraphic conditions very great differences in the amounts of extractable metallic cations were often found within small vertical distances in the soil sections.

The water level in most of the lakes has been lowered and the biotopes were situated in areas probably not accessible to *Phragmites* until after the lowering. In 32 Tåkern and 36 Krankesjön *Phragmites* has overgrown gyttja, in 33—34 W. Ringsjön minerogenic bottom.

In the large *Phragmites* reed-beds the accumulation of organic matter is considerable and due to this characteristic stratigraphic conditions are developed. Thus in 33—34 W. Ringsjön a coarse gyttja is found above the leached surface layer of the minerogenic bottom. This is downwardly followed by unleached soils.

In gyttja and leached minerogenic soils the amounts of extractable metallic cations were only of the order of 50—80 meq/l in 30 Jägern, 33—34 W. Ringsjön, 35 Krankesjön, and 37 Björkesåkrasjön. From the gyttja in 32 Tåkern up to about 110 and in 36 Krankesjön to 610 meq/l were obtained.

The clayey and clay gyttja as well as the clay in 30 Jägern contained about 150 and most layers in 38—39 Tystrup Sö 150—300 meq/l. Very high values, 1000—6000 meq/l were obtained from calcareous minerogenic soils in Scanian and Zealandian biotopes.

As for the percentage of neutralization the lowest figures, 62—75 %, derive from the superficial coarse gyttja, evidently recently accumulated in the reed-

beds. In other soils where it was possible to determine this quality the figures were from ca. 80 to 100 %.

The greatest amounts of extractable Na were found in 30 Jägern. In the other biotopes this element was fairly evenly distributed. Also extractable K showed the same pattern of distribution, the lowest figures being found in gyttja and gyttja-like (Tystrup Sö) soils.

The amounts of extractable Ca were correlated with the total amounts of extractable metallic cations. However, in 30 Jägern proportionally great amounts of Mg and Fe were also extractable.

The lowest Ca/Mg quotients were found in 30 Jägern, 1.2—2.0, and in 32 Tåkern, 3.2—4.0. With the exception of the superficial gyttja and upper leached sand in 33—34 W. Ringsjön the quotients were much greater in Scania and Zealand. The biotopes in Jägern and Tåkern were the only ones in which particles of CaCO_3 were not found in any layer in the vertical sections.

B. *Phragmites communis*

The polyploid level of the clone in 30 Jägern was hexaploid, in all other biotopes clones at the tetraploid level occurred (Table 37).

The percentage of apparently morphologically good pollen was not lower than 80 % in any of the investigated clones, the highest found value, 95 %, was from 36 Krankesjön (Table 37).

The hexaploid clone in 30 Jägern had the largest pollen grains, the mean diameter about 32 μm . In the tetraploid clones of the other biotopes the diameter was within the range of about 26—29 μm (Table 38).

The rhizosphere was found to have the smallest vertical extension, about 80 cm, in, e.g., 33 W. Ringsjön (calcareous sand covered with gyttja) and 37 Björkesåkrasjön (calcareous hard moraine clay covered with gyttja). It was characteristic of the biotopes with a thin layer of organogenic soil over a minerogenic one that the rhizome and root system was concentrated mainly to the organogenic layer.

Among the tetraploid clones panicle shoots with an average length (Fig. 108, Table 43) somewhat above 400 cm occurred in 34 W. Ringsjön and 38 Tystrup Sö. The corresponding shoots were about 300—350 cm in 32 Tåkern and 37 Björkesåkrasjön (at the beginning of the investigation), but only 250—300 cm in 33 W. Ringsjön, 35—36 Krankesjön, and 39 Tystrup Sö. The hexaploid clone in 30 Jägern had a panicle shoot length of about 400 cm. Compare also the shoot weights in Table 41.

The weight and dimensions of shoot qualities along a horizontal section through a reed girdle were analysed in 31 A—D Jägern (Fig. 91, Table 40). Though the differences between different zones were fairly small, the best developmental conditions obviously were realized in the landward half of the girdle.

The tall panicle shoots in the hexaploid clone in 30 Jägern and in the tetraploid in 34 W. Ringsjön had a leaf area per shoot of 14—15 dm^2 (Table 43). Among the other tetraploids the leaf area could be estimated as follows: in 38 Tystrup Sö considerably greater than 15 dm^2 , in 37 Björkesåkrasjön 8 dm^2 and in 32 Tåkern, 33 W. Ringsjön and 35—36 Krankesjön about 5.0—6.5 dm^2 .

The length of the stomatal guard-cells of the middle leaves was greater than 27 μm in the hexaploid clone in 30 Jägern. In the tetraploid clone in 38 Tystrup Sö it was about 25 μm and in all other tetraploids definitely smaller than 25 μm . In the 30 Jägern clone the stomatal density was less than 1000, but in the tetraploids approximately or more than 1000 per mm^2 (Table 39).

The lowest shoot density, ca. 25, occurred in 30 Jägern and 35 Krankesjön. In 38 Tystrup Sö, 34 W. Ringsjön, and 37 Björkesåkrasjön it was 35—50 and in 32 Tåkern and 39 Tystrup Sö 60—70. The highest densities were found in 33 W. Ringsjön with 110 and 36 Krankesjön with ca. 140.

In all biotopes the highest found panicle frequency amounted to 70—85 %. However, in some biotopes considerable variations were noted between different years. For example, in 1962, the frequency was as low as 25 % in 33 W. Ringsjön, 40 % in 34 W. Ringsjön, ca. 20 % in 38 Tystrup Sö and 55 % in 39 Tystrup Sö.

The earliest flowering occurred in the

middle or latter half of August in 32 Tåkern and 35 Krankesjön, while the latest, in early October, took place in 38 Tystrup Sö.

The smallest leaf area per m^2 (Table 43), about 130 dm^2 , was found in 35 Krankesjön. It was 300—400 dm^2 in 30 Jägern, 37 Björkesåkrasjön, and 32 Tåkern, and 500—600 dm^2 in 33—34 W. Ringsjön. The largest leaf area occurred in the densely growing but divided reed-bed in 36 Krankesjön, where it was about 800 dm^2 .

Also with respect to standing crop (Table 42) 35 Krankesjön gave the lowest value, ca. 500 g, and 36 Krankesjön the highest, ca. 2400 g. Values from 1200 to 1400 were found in 37 Björkesåkrasjön, 39 Tystrup Sö and 32 Tåkern. As for biotopes 33—34 W. Ringsjön and 38 Tystrup Sö the differences between the sampling years 1962 and 1963 were considerable, viz., an increase from 1500 to 1700, from 1600 to 2200 and from 1300 to 2200 g respectively.

The analyses of expressed sap and press-cakes (Tables 44—45) are discussed in the Synthetic Part.



Fig. 108. Panicles and shoots from biotopes within eutrophic regions in South Sweden and Zealand. Biotopes represented by panicles from different years: 32 (1962 and 1963), 33 (1962 and 1966), 34 (1962 and 1966), 38 (1962 and 1963) and 39 (1962 and 1966).

TABLE 36. Water analyses.

Biotope	Date	SW IWP, IWS	Samp- ling level cm	Water, Pit depth cm	θ °C	Col mg/l	Sp.cond. µS	pH	µmol/l							Alk µeq/l
									Na	K	Mg	Ca	Fe	Cl	P	
30 Jägern	630822	SW	0	15	12.6	100	89	6.5	230	29	70	270	•	100	•	584
32 Tåkern	630823	SW	0	15	11.9	160	250	6.9	210	31	200	1160	8	185	•	1660
33 W.Ringsjön	630718	SW	0	25	16.1	30	240	6.8	360	19	90	1020	3	375	3.0	1700
	640625	SW	0	30	14.2	60	160	6.6	280	15	30	710	3	35	•	1210
	640806	IWP	-8	30	12.6	80	300	6.6	420	31	70	1450	8	175	•	2770
	640812	IWS	-15	•	•	320	260	7.5	490	28	110	1190	9	285	•	1460
	640812	IWS	-65	•	•	40	770	8.2	1190	38	530	3520	12	250	•	9150
34 W.Ringsjön	630718	SW	0	55	16.2	30	240	7.0	370	47	100	1040	3	410	2.6	1640
	640625	SW	0	45	14.0	70	150	6.6	320	21	20	660	3	170	•	1200
	640806	IWP	-12	45	12.2	70	460	6.4	750	27	130	2290	5	115	•	4950
	640812	IWS	-20	•	•	280	350	7.8	600	15	180	1840	12	165	•	2970
	640812	IWS	-85	•	•	35	970	8.0	2330	51	530	3520	10	1150	•	9500
35 Krankesjön	640807	SW	0	20	19.6	25	380	7.9	570	86	240	1700	2	650	•	2300
	640918	SW	0	•	12.8	25	380	8.1	550	89	280	1700	2	645	•	2230
	640807	SW	0	5	20.6	25	380	7.8	570	86	240	1700	2	650	•	2290
36 Krankesjön	640918	SW	0	•	12.2	30	410	7.7	540	100	240	1940	5	640	•	2540
	640918	IWS	-35	•	•	120	1100	8.1	830	38	840	7460	42	880	•	11120
	640918	IWS	-80	•	•	80	1000	7.9	680	47	1050	6280	45	825	•	11820
37 Björkesåkrasjön	640827	IWP	-28	42	13.0	100	670	6.5	450	18	120	4150	17	30	•	6390
	640827	SW*1	0	•	24.9	55	220	9.1	550	65	50	900	1	565	•	934
38 Tystrup Sö	630831	SW	0	•	17.3	20	510	8.0	1210	185	250	1960	0.8	1230	5.7	3410
	640824	SW	0	•	16.3	20	550	8.8	1240	145	240	2430	0.5	1290	•	3950
39 Tystrup Sö	630831	SW	0	•	17.3	20	510	8.0	1220	185	260	1960	0.8	1230	5.2	3420
	640824	SW	0	•	16.3	20	550	8.7	1240	145	240	2430	0.5	1290	•	3950

*1 = sampling site situated 9 m lakewards from the biotope.

TABLE 39. Biometric analyses of stomata.

Biotope	Date	Shoot type	Shoot length cm	Leaf				Guard-cell length					Stomata density	Leaf area x stomata density	
				No.	Inser- tion level cm	Length cm	Breadth mm	Area cm ²	n	m	µm	s	no./mm ²	x 1000	
30 Jägern	630822	PS	450	2	299	64	52	178	50	30.0	0.26	1.86	10	670	119
				6	355	68	41	144	50	27.7	0.35	2.47	10	850	122
	630822	PS	440	10	398	63	25	75	50	25.8	0.17	1.22	10	940	71
				7	350	66	40	131	50	27.3	0.23	1.65	10	910	119
32 Tåkern	630823	PS	334	2	222	45	37	85	50	24.5	0.26	1.85	10	850	72
				5	270	48	33	83	50	23.1	0.24	1.68	10	1000	83
	630823	PS	368	8	304	41	23	53	50	23.3	0.23	1.60	10	940	50
				6	297	48	36	82	50	24.0	0.16	1.10	10	1040	85
33 W.Ringsjön	630907	PS	289	2	201	50	37	97	50	23.6	0.19	1.34	10	1220	118
				6	239	41	30	68	50	21.9	0.20	1.38	10	1290	88
	630907	PS	288	8	261	35	20	37	50	21.5	0.15	1.05	10	1320	49
				6	238	42	29	60	50	22.5	0.19	1.38	10	1290	77
34 W.Ringsjön	630907	PS	441	3	286	51	50	132	50	23.7	0.19	1.34	10	1270	168
				9	370	53	42	116	50	22.4	0.20	1.45	10	1720	200
	630907	PS	442	15	412	41	21	51	50	20.3	0.17	1.17	10	1730	88
				9	368	53	45	135	50	22.5	0.21	1.47	10	1590	215
35 Krankesjön	660827	PS	249	1	139	35	36	79	50	25.9	0.22	1.58	10	960	76
				5	193	43	35	81	50	23.6	0.26	1.83	10	1130	92
	660827	PS	263	8	221	34	24	45	50	22.3	0.19	1.37	10	1340	60
				5	197	45	35	81	50	22.7	0.20	1.44	10	1350	109
36 Krankesjön	630907	PS	286	3	204	53	32	91	50	22.4	0.19	1.33	10	1300	118
				8	241	49	26	64	50	21.4	0.18	1.21	10	1440	92
	630907	PS	276	12	251	34	18	32	50	23.2	0.18	1.29	10	1320	42
				6	222	54	31	80	50	21.6	0.15	1.04	10	1430	114
37 Björkesåkrasjön	660827	PS	297	1	136	35	32	65	50	25.9	0.22	1.58	10	960	62
				6	217	45	34	74	50	24.4	0.26	1.81	10	1070	109
	660827	PS	319	11	261	37	23	45	50	23.3	0.27	1.90	10	1410	63
				7	227	45	32	77	50	23.5	0.23	1.66	10	1550	119
38 Tystrup Sö	621009	PS	412	1	218	-	-	-	50	26.3	0.28	1.97	10	810	-
				9	349	-	47	-	50	25.5	0.20	1.41	10	1190	-
	621009	PS	433	14	392	-	32	-	50	25.0	0.20	1.40	10	1340	-
				1	195	-	51	-	50	28.0	0.27	1.88	10	750	-
39 Tystrup Sö	621009	PS	275	9	336	-	46	-	50	24.6	0.24	1.71	10	1200	-
				16	401	53	32	91	50	24.4	0.22	1.53	10	1370	125
	621009	PS	277	2	127	42	42	106	50	25.9	0.23	1.59	10	930	99
				5	197	-	39	-	50	24.3	0.26	1.81	10	1360	-
621009	PS	275	10	252	43	34	86	50	23.1	0.22	1.52	10	1480	127	
			3	181	-	43	-	50	25.0	0.30	2.09	10	1130	-	
			6	227	45	40	113	50	24.3	0.27	1.92	10	1210	137	
9	251	44	34	85	50	23.4	0.25	1.80	10	1290	110				

TABLE 40. Biometric analyses of shoots from biotopes 31 A-D Jägern (see fig. in description of biotopes). Sampling method 2. Weights in g/shoot.

Date	Sampling square	Number and type of shoots PS/WFS	Weights								Shoot length cm			Dist. base-1st green leaf, cm			Panicle length cm			Diameter of base internode mm			Diameter of internode at 1st green leaf, mm			Number of internodes per PS			Internode length cm				Number of green leaves per PS				Leaf length cm				Leaf breadth mm				Leaf area per PS dm ²		Shoot density
			Panicles		Leaves		Rest		Total		m	e	s	m	e	s	m	e	s	m	e	s	m	e	s	n	m	e	s	m	e	s	n	m	e	s	n	m	e	s							
			DM	AW	DM	AW	DM	AW	DM	AW																																					
550818	A	15/1 = 16	2.70	0.15	7.3	0.74	28	1.25	38	2.13	337	6.40	24.8	164	2.92	11.3	36.7	1.31	5.08	9.8	0.45	1.76	7.6	0.28	1.07	19.9	0.28	1.10	284	15.0	0.38	6.33	11.3	0.21	0.82	170	55.6	0.62	8.07	170	32.5	0.69	9.03	10.6	26		
	B	16/0 = 16	2.42	0.14	8.7	0.84	29	1.37	40	2.35	318	6.50	26.0	162	3.46	13.8	34.9	1.77	7.08	10.2	0.38	1.53	7.9	0.23	0.91	21.2	0.16	0.66	323	13.4	0.29	5.18	11.7	0.20	0.79	187	55.1	0.66	8.96	187	34.7	0.69	9.38	11.9	34		
	C	14/2 = 16	2.08	0.11	8.9	0.81	29	1.28	39	2.18	328	5.71	21.4	168	2.97	11.1	35.6	1.77	6.62	11.1	0.43	1.61	8.1	0.31	1.15	21.8	0.19	0.70	291	13.4	0.31	5.25	11.9	0.36	1.35	170	60.6	0.70	9.12	170	35.0	0.67	8.76	13.1	24		
	D	8/8 = 16	1.07	0.06	5.7	0.61	23	1.05	30	1.68	330	9.34	26.5	200	3.78	10.7	29.0	2.92	8.23	12.4	0.21	0.60	7.6	0.34	0.96	23.4	0.80	2.26	178	13.0	0.48	6.42	12.1	0.35	0.99	97	54.0	0.75	7.43	97	32.9	0.88	8.62	11.3	24		
570912	A	15/1 = 16	1.99	0.09	6.1	0.51	20	0.78	28	1.36	282	6.42	24.9	139	1.99	7.7	32.3	1.32	4.94	8.9	0.34	1.30	6.7	0.18	0.69	18.9	0.23	0.88	284	13.5	0.30	5.06	10.7	0.23	0.88	161	51.7	0.51	6.48	161	30.4	0.60	7.64	8.8	41		
	B	15/1 = 16	2.98	0.14	7.3	0.65	27	1.05	37	1.83	316	6.40	24.8	154	4.13	16.0	36.6	1.07	4.15	9.9	0.44	1.73	7.3	0.23	0.89	19.6	0.27	1.06	294	14.3	0.31	5.26	10.5	0.17	0.64	157	54.7	0.43	5.43	157	33.8	0.59	7.58	9.8	33		
	C	15/1 = 16	1.98	0.09	6.9	0.56	22	0.84	31	1.47	304	4.96	19.2	152	2.70	10.5	31.6	1.35	5.23	9.5	0.30	1.17	7.2	0.26	1.01	19.5	0.24	0.92	293	14.0	0.31	5.35	11.3	0.18	0.70	169	52.1	0.51	6.65	169	31.8	0.63	8.15	9.8	34		
	D	12/4 = 16	1.33	0.06	6.8	0.54	24	0.88	31	1.46	291	8.06	27.9	166	3.98	13.8	29.9	1.40	4.20	11.1	0.38	1.31	7.2	0.17	0.60	22.2	0.39	1.42	268	11.9	0.29	4.72	12.2	0.17	0.58	145	49.7	0.51	6.12	145	31.6	0.62	7.51	9.9	27		

TABLE 41. Shoot weights (g/shoot).

Biotope	Date	Sampling method (no.) and area (m ²)	Number and type of shoots PS/WFS	Panicles		Leaves		Rest		Total	
				DM	AW	DM	AW	DM	AW	DM	A
30 Jägern	570910	2/1	16/0 = 16	4.5	0.19	12	1.0	43	1.7	59	3.0
		2/1	16/0 = 16	4.6	0.19	12	1.0	47	1.7	63	2.9
		2/1	16/0 = 16	5.2	0.22	10	0.84	43	1.5	58	2.6
		2/1	16/0 = 16	4.5	0.20	9.5	0.83	40	1.5	54	2.5
32 Tåkern	550816	2/1	16/0 = 16	2.0	0.12	5.6	0.61	31	1.4	38	2.1
	560809	2/1	16/0 = 16	1.7	0.11	5.5	0.60	26	1.2	33	1.9
		1	16/0 = 16	2.5	0.13	5.4	0.60	24	0.99	32	1.7
37 Björkesåkrasjön	550905	2/1	16/0 = 16	1.2	0.07	5.5	0.42	25	1.0	32	1.5
		2/1	15/1 = 16	0.93	0.06	4.9	0.41	22	0.87	27	1.3
		2/1	16/0 = 16	1.0	0.06	6.2	0.48	27	1.2	34	1.7
		2/1	15/1 = 16	1.1	0.07	5.3	0.46	24	1.1	30	1.6

TABLE 43. Biometric analyses of shoots.

Biotope	Date	Sampling method (no.) and area (m ²)	Shoot type	Number of shoots	Shoot length cm			Dist. base-1st green leaf, cm			Panicle length cm			Diameter of base internode mm			Diameter of internode at 1st green leaf, mm			Number of internodes per shoot	Internode length cm			Number of green leaves per shoot			Leaf length cm			Leaf breadth mm			Leaf area, dm ² per shoot per m ² per m ² WPS PS PS + WPS							
					m	e	s	m	e	s	m	e	s	m	e	s	m	e	s		m	e	s	n	m	e	s	n	m	e	s	n	m	e	s					
30 Jägern	570910	2/4	PS	64	398	2.40	19.2	186	2.36	18.9	42.4	0.43	3.42	11.1	0.06	0.49	9.3	0.04	0.32	19.9	0.18	1.41	1271	18.1	0.20	7.04	11.6	0.12	0.94	743	60.1	0.28	7.50	743	37.5	0.31	8.33	13.7	-	-
	630822	3/1	PS	16	408	6.62	26.5	211	3.74	14.9	37.6	1.81	7.24	10.5	0.35	1.45	8.5	0.29	1.16	20.1	0.29	1.11	321	18.2	0.49	8.74	11.4	0.16	0.63	183	62.5	0.61	8.25	183	36.6	0.65	8.77	13.6	217	282
			WFS	8	272	14.5	41.0	191	12.3	34.7	-	-	-	7.8	0.49	1.40	5.5	0.44	1.21	16.3	0.53	1.51	131	16.5	0.83	9.50	8.9	0.40	1.13	71	51.4	1.09	9.16	71	25.9	0.85	7.13	6.3	50	-
	560809	1	PS	16	318	4.00	16.0	-	-	-	24.4	0.80	3.18	9.7	0.31	1.26	7.5	0.11	0.46	16.6	0.33	1.31	266	17.7	0.48	7.83	9.8	0.23	0.91	152	40.8	0.49	6.04	154	32.9	0.46	5.71	5.7	-	-
32 Tåkern	620920	3/1	PS	46	345	4.26	28.9	213	2.15	14.8	-	-	-	9.6	0.25	1.68	6.5	0.14	0.95	20.3	0.24	1.65	953	15.7	0.25	7.59	10.3	0.17	1.17	-	-	-	-	482	29.5	0.28	6.24	-	-	-
			WFS	9	277	17.3	52.0	183	9.59	28.8	-	-	-	6.7	0.37	1.10	4.3	0.20	0.60	16.1	0.56	1.69	145	14.5	0.60	7.25	7.6	0.58	1.74	-	-	-	-	68	24.3	0.95	7.83	-	-	-
	620920	3/1	PS	34	362	5.33	31.1	243	3.04	17.7	-	-	-	10.0	0.30	1.73	5.8	0.18	1.04	21.8	0.30	1.78	740	15.4	0.30	8.20	10.0	0.20	1.14	-	-	-	-	339	27.6	0.35	6.46	-	-	-
	630823	3/1	WFS	9	318	7.38	22.1	230	5.89	17.7	-	-	-	9.2	0.52	1.57	5.1	0.26	0.79	18.3	0.71	2.12	165	16.3	0.66	8.48	8.6	0.69	2.07	-	-	-	-	77	25.3	0.69	6.07	-	-	-
33 W.Ringsjön	630823	3/1	PS	58	317	3.61	27.5	190	2.39	18.2	25.2	0.59	4.21	8.4	0.21	1.57	5.4	0.14	1.07	19.8	0.19	1.44	1145	14.5	0.20	6.79	9.4	0.16	1.23	545	41.6	0.22	5.15	545	26.7	0.27	6.23	5.2	302	387
			WFS	16	234	7.97	31.9	185	6.45	25.8	-	-	-	7.1	0.51	2.05	3.7	0.31	1.23	17.0	0.61	2.45	272	13.1	0.43	7.17	6.6	0.50	2.00	106	38.2	0.51	5.24	106	22.5	0.57	5.86	3.1	50	-
	621001	3/1	PS	27	250	4.69	24.4	147	2.22	11.5	18.0	0.47	2.42	7.7	0.18	0.91	5.1	0.13	0.65	19.7	0.20	1.04	531	13.5	0.16	3.68	10.0	0.23	1.21	-	-	-	-	269	27.9	0.40	6.48	-	-	-
			WFS	95	196	3.22	31.4	141	1.46	13.5	-	-	-	6.4	0.09	0.90	4.1	0.08	0.74	15.6	0.28	2.75	1479	11.9	0.12	4.56	6.9	0.31	3.06	-	-	-	-	652	26.0	0.18	4.48	-	-	-
34 W.Ringsjön	630907	3/1	PS	64	284	1.77	14.1	180	2.00	16.0	23.5	0.48	3.69	8.6	0.13	1.04	5.1	0.09	0.71	20.6	0.51	1.14	103	12.5	0.60	6.09	10.0	0.12	1.00	637	41.3	0.26	6.44	637	29.2	0.28	7.17	6.5	416	524
			WFS	24	214	4.58	22.5	159	4.02	19.7	-	-	-	6.9	0.16	0.77	3.8	0.15	0.73	19.3	0.32	1.05	212	10.9	0.43	6.20	8.8	0.44	2.17	211	36.9	0.46	6.62	211	24.0	0.40	5.78	4.5	108	-
	621002	3/1	PS	23	422	5.41	25.9	237	3.74	18.0	16.5	0.72	2.60	14.6	0.36	1.72	8.6	0.18	0.85	24.3	0.32	1.54	558	16.1	0.31	7.21	14.7	0.21	1.02	-	-	-	-	338	36.6	0.45	8.33	-	-	-
			WFS	19	304	18.1	78.8	208	6.90	28.5	-	-	-	10.3	0.63	2.74	6.5	0.34	1.40	19.2	0.94	4.09	365	15.5	0.38	7.16	10.3	1.07	4.68	-	-	-	-	195	31.8	0.52	7.22	15.0	495	581
35 Krankesjön	630907	3/1	PS	33	433	4.65	26.7	244	2.23	12.8	25.2	0.54	3.11	14.0	0.40	2.32	8.8	0.16	0.96	24.8	0.27	1.54	820	16.3	0.30	8.67	14.6	0.11	0.65	483	48.1	0.21	4.72	483	38.1	0.42	9.26	9.1	73	-
			WFS	8	325	21.1	59.6	233	9.43	26.7	-	-	-	9.7	0.61	1.72	5.8	0.38	1.07	21.1	0.67	1.88	169	14.6	0.70	9.16	10.9	1.33	3.76	-	-	-	-	92	32.0	0.89	8.51	-	-	-
	640902	3/2	PS	16	252	4.24	17.0	145	3.58	14.3	21.6	0.80	3.18	8.8	0.34	1.35	5.9	0.24	0.95	19.6	0.29	1.15	313	11.8	0.22	3.86	8.9	0.23	0.93	137	39.0	0.50	5.84	137	30.1	0.67	7.81	5.5	117	126
			WFS	5	168	2.92	6.52	127	4.19	9.36	-	-	-	5.8	0.12	0.27	3.5	0.17	0.39	17.2	0.20	0.45	86	9.5	0.43	4.02	8.0	0.32	0.71	40	29.8	1.11	7.02	40	19.2	0.98	6.18	2.6	9	-
36 Krankesjön	630907	3/0.25	PS	27	265	3.12	16.6	174	2.40	12.7	21.6	0.66	3.39	8.2	0.19	1.00	5.0	0.10	0.52	21.6	0.22	1.15	584	11.2	0.26	6.31	11.6	0.18	0.97	314	44.2	0.49	8.79	314	24.9	0.32	5.70	6.5	698	807
			WFS	6	197	6.55	16.0	167	8.82	21.6	-	-	-	7.0	0.52	1.28	3.6	0.21	0.52	17.5	0.76	1.87	105	10.6	0.69	7.07	7.8	1.30	3.19	47	41.1	1.16	7.92	47	22.4	0.70	4.83	3.9	109	-
	550905	2/4	PS	62	330	3.76	29.6	199	3.11	24.5	31.1	1.11	6.06	10.4	0.27	2.12	5.8	0.12	0.95	23.4	0.40	3.16	1450	12.8	0.15	5.90	11.7	0.09	0.68	723	42.1	0.14	3.72	726	29.2	0.22	5.93	8.0	-	-
	640827	3/1	PS	10	223	10.3	32.6	131	6.49	20.5	34.7	0.83	2.63	8.8	0.22	0.68	6.9	0.28	0.84	20.3	0.45	1.42	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
37 Björkesåkrasjön			WFS	3	203	-	-	101	-	-	-	-	-	5.9	-	-	4.9	-	-	19.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	621009	3/1	PS	7	412	6.46	17.1	195	4.61	12.2	17.0	1.79	4.38	20.0	1.39	3.67	11.1	0.70	1.84	30.7	1.04	2.75	215	12.7	0.38	5.50	17.3	0.42	1.11	-	-	-	-	121	42.8	0.82	9.06	-	-	-
			WFS	24	337	8.43	41.3	176	3.40	16.6	-	-	-	13.8	0.45	2.19	8.6	0.30	1.46	25.5	0.70	3.43	611	12.6	0.25	6.27	14.5	0.56	2.75	-	-	-	-	349	37.7	0.41	7.58	-	-	-
	630831	3/1	PS	32	421	4.06	23.0	190	3.28	18.6	28.9	0.67	3.13	17.7	0.56	3.15	10.5	0.20	1.11	27.1	0.20	1.16	868	14.4	0.25	7.43	16.1	0.15	0.83	-	-	-	-	516	41.8	0.38	8.68	-	-	-
38 Tystrup Sö			WFS	9	308	17.9	53.8	171	7.33	22.0	-	-	-	15.7	0.96	2.88	10.9	0.38	1.15	20.3	1.27	3.81	183	14.0	0.63	8.51	11.0	0.98	2.95	-	-	-	-	99	43.6	0.69	6.85	-	-	-
	621009	3/1	PS	46	267	5.03	30.6	145	3.19	21.6	25.9	0.73	3.35	8.3	0.15	1.01	5.8	0.09	0.62	18.3	0.25	1.70	842	13.4	0.24	6.88	9.4	0.14	0.93	-	-	-	-	432	36.2	0.24	5.01	-	-	-
			WFS	18	203	8.04	34.1	143	5.73	24.3	-	-	-	7.0	0.24	1.00	4.7	0.23	0.96	15.9	0.36	1.51	287	12.4	0.38	6.50	8.1	0.45	1.89	-	-	-	-	145	31.8	0.42	5.07	-	-	-
	630831	3/1	PS	48	299	5.04	34.9	186	1.93	13.3	28.0	0.66	3.99	9.3	0.20	1.38	6.0	0.14	0.99	18.4	0.21	1.44	883	14.9	0.26	7.61	9.5	0.12	0.85	-	-	-	-	457	39.7	0.35	7.53	-	-	-
39 Tystrup Sö			WFS	13	220	6.23	22.5	177	3.17	11.4	-	-	-	7.1	0.21	0.76	4.3	0.33	1.19	16.1	0.59	2.14	209	12.9	0.57	8.21	7.3	0.62	2.25	-	-	-	-	96	34.1	0.62	6.11	-	-	-

TABLE 45. Analyses of press-cakes from biotopes 33-34 W. Ringsjön. As for sampling date, environmental conditions at samplings etc. see corresponding sample numbers in Table 44.

Shoot part	Bio- tope	Sample no.	Na	K	Mg	Ca	Fe
			mmol/100 g DM of press-cake				
Rhizomes	33	81/63	1.41	12.1	1.33	0.55	0.07
	34	78/63	2.67	15.0	0.88	0.56	0.09
Lower leaves	33	80/63	0.16	6.84	5.3	12	0.2

V. Biotopes on the Coasts of South Sweden and Zealand

With respect to several environmental factors the coastal *Phragmites* biotopes differed greatly among themselves. However, they were chosen so that they represent conditions typically prevailing in the coastal reaches within which they were situated.

The parts of the South Swedish coast represented by biotopes are the eastern (40 Orrekulle) and western (41—42 Pukavik) parts of Blekinge, the middle part of the Sound (43—44 Lödösnäs, 45 A—C Bjärred), the middle part of Halland (47 Ängen), and the south part of Bohuslän (48 Hakenäs). Furthermore, the southeastern coast of Zealand is represented (46 Praestö Fjord). See the map in Fig. 4.

The salinity in the southern Baltic and Kattegatt is subject to considerable variations during the year. The average salinity of the surface water is seen in Fig. 109 and the annual fluctuations in the open sea in Fig. 110. "The salinity variations in the superficial layers of the Baltic proper are mainly seasonally conditioned; the highest values are reached in autumn and winter, the lowest, because of the melting of the snow,

in spring and summer. The dilution in spring, of course, first affects the coastal waters and later the open sea." (SEGERSTRÅLE 1957, p. 758.)

Now and then greater influxes into the Baltic of water with high salinity takes place, which is of essential importance for many organisms (SEGERSTRÅLE 1965).

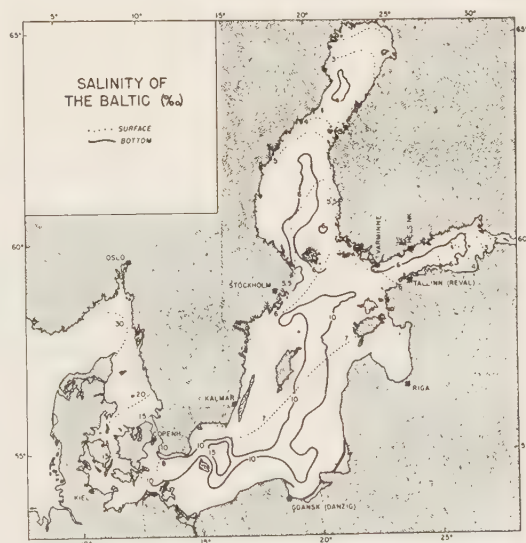


Fig. 109. The average salinity of the Baltic and adjacent waters. (From SEGERSTRÅLE 1957.)

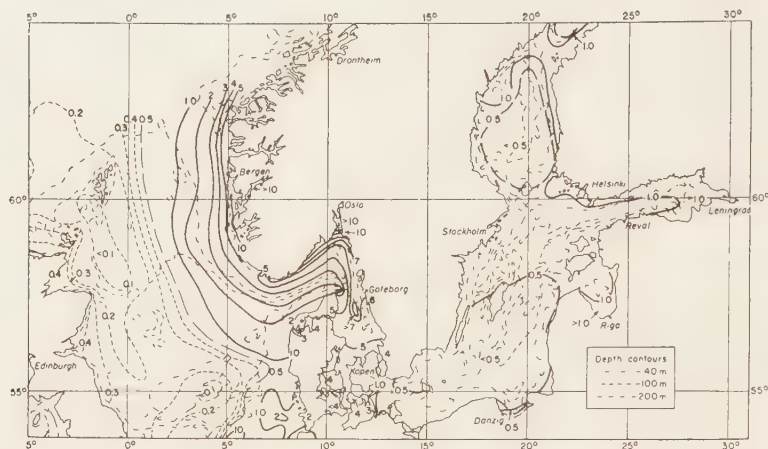


Fig. 110. The annual fluctuations of the salinity (‰) in the Baltic and adjacent waters. (From SEGERSTRÅLE 1957.)

In the coastal regions irregular, sudden and great fluctuations occur in the salinity as a result of variations in the supply of water from the open sea and of fresh water from the rivers. In winter the water could be highly diluted under the ice along the coast in the vicinity of river mouths (SEGERSTRÅLE 1951, LUTHER 1951 p. 66).

The tides are weak but recognizable at the northern part of the Swedish west coast and are insignificant in the Baltic (HILDING 1948, GILLNER 1960). On the other hand, there are greater water level changes with an annual rhythm (DU RIETZ 1930, BERGSTEN 1931), but the irregular, often suddenly occurring fluc-

tuations, caused by the wind, have the greatest amplitude. See Figs. 74 and 111.

The minerogenic shores consist of moraine and sediments washed out of this. In the *Phragmites* biotopes there are often clayey soils under a superficial coarse-grained layer. In sheltered bays bottom areas with sediments containing organogenic matter, often clay gyttja, are accessible to *Phragmites*.

The seashore meadows in considerable coastal reaches are to a large extent used as grazing ground. In these meadows *Phragmites* fairly often occurs as scattered stands of very small shoots (Fig. 112). Discontinuance of the grazing should, without doubt, result in a great

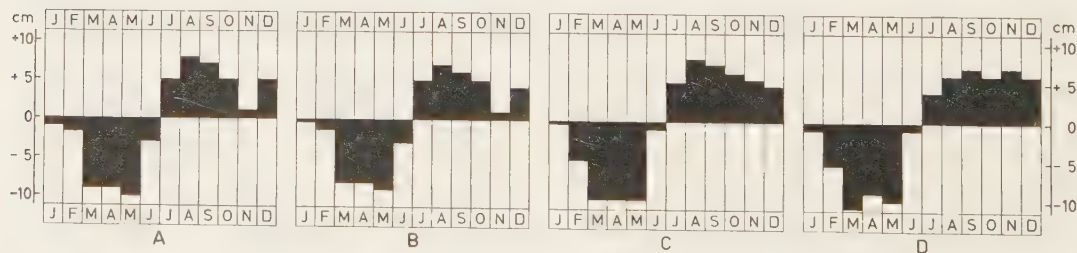


Fig. 111. The monthly normal heights of the sea level at Karlskrona (A), Ystad (B), Varberg (C) and Smögen (D).

Fig. 112. Small *Phragmites* shoots developed in a grazed seashore meadow. Ängen, north of Varberg. — Photo S. Björk 620804.



increase in the areas overgrown by *Phragmites*. The differences with respect to the quantitative development of *Phragmites* in grazed and ungrazed parts of a shore reach are often striking (Fig. 113).

Investigations of vegetation and environmental conditions have been carried out by GRETA & G. E. DU RIETZ (1925) and BERGLUND (1963 a) in parts of the archipelago of Eastern Blekinge and by

BERGLUND et al. (1963) in different parts of the coast of Blekinge. The southeastern coast of the Sound is treated by DAHLBECK (1945), the Praestö Fjord area by HANSEN (1944), JENSEN (1944), and OLSEN (1945). GILLNER (1960) carried out extensive investigations of the Swedish west coast (Halland and Bohuslän). The investigations concerning salt marsh vegetation in Southern Sweden are reviewed by GILLNER (1965).

Fig. 113. Seashore meadow at Praestö Fjord, Zealand. The fence of barbed wire separates a grazed area from an ungrazed one overgrown with dense *Phragmites*. — Photo S. Björk 630901.





Fig. 114. Orrekulle. Biotope 40 located in the outer zone of the reed-bed. — Photo S. Björk 630910.

Orrekulle

With Biotope 40

A. Environment

Situation (Fig. 4). Inside the archipelago of Karlskrona, immediately west of the mouth of the stream Nättrabyån.

Physiographic survey (Fig. 114). In the sheltered bays along the coast of Blekinge as well as in the archipelago *Phragmites communis* is one of the most common hyperhydric species, frequently occurring in large stands. Often the river mouths are surrounded by vast reed-beds. Biotope 40 represents the conditions in one of these.

West of the mouth of Nättrabyån a vast area is covered by a continuous *Phragmites* reed-bed. In this a zonation conformable to the shore was found. In the landward zone, with the oldest part of the stand, *Phragmites* had fairly short shoots. In the seaward zone (the youngest part of the stand) the shoots were considerably longer and the density greater, i.e., the standing crop was markedly higher than in the landward zone, where the land formation processes are advanced. There was no sharp limit between these extreme marginal zones. The biotope was situated in the outer zone, about 30 m landwards from the outer margin. It was exposed to winds from all directions. No wave action was noticeable.

The *Phragmites* stand was quite pure. The dry stems often remained for at least one vegetation period.

The water (Table 47). As for water level fluctuations see Fig. 111. On the basis of the records made at Kungsholmen (Karlskrona), the water depth in the biotope varied from 0 to 64 cm during May to September in the years 1963—1964.

Analyses of sea water from 5 sampling stations in the vicinity of Orrekulle were made by LINDGREN (in RODHE et al. 1962). Three of the stations were situated to the east and two to the west of Orrekulle, all within a maximum distance of 14 km. All stations were situated in sheltered bays and sounds. Samples were taken monthly from May to September 1960 and April and May 1961. The analytical data indicate that the quality of the surface water was much the same at all five stations. The mean of the specific conductivity was 9.59 mS ($n=35$, min.=7.55, max.=10.95). With respect to the major constituents the ionic composition of the water from all stations showed only small differences from the Baltic Sea water.

Undoubtedly the changes in the quality of the surface water during the vegetation period are great in the biotope due to the proximity to the mouth

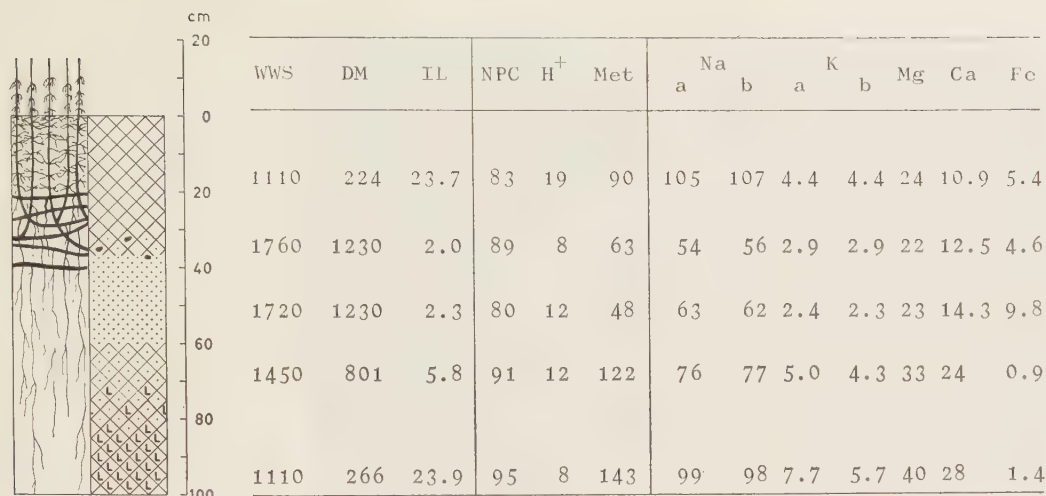


Fig. 115. Biotope 40 Orrekulle 640830. Vertical section and soil analyses.

of Nättrabyån. The specific conductivity of the stream water ca. 2.5 km upstream from the mouth was 160 μ S in Oct. 1959 (very weak water flow after exceptionally dry summer) and 85 in Aug. 1960 (strong water flow after rainy period). In surface and interstitial water sampled in the biotope the specific conductivity has varied from 4.9 to 11.2 mS.

The bottom (Fig. 115).

Stratigraphy:

- 0— 5 cm Coarse brown detritus.
- 5— 30 cm Loose dark brownish gyttja, H₂S-smelling.
- 30— 37 cm Transition layer of sand with dark grey brown gyttja. Small stones occurred.
- 37— 72 cm Dark grey brown, fine sand with some gyttja. Here and there practically pure sand layers.
- 72—100 cm Very dense, elastic, dark brown clay gyttja to clayey gyttja and nearly pure gyttja. Downwardly decreasing amount of sand.

There was a minimum in the amount of extractable metallic cations as well as in the percentage of neutralization in the middle sandy part. From there also the

lowest values for extractable Na, K, and Mg were obtained. For Ca there was a clear increasing trend downwards.

B. *Phragmites communis*

Rhizomes and roots (Fig. 115). The occurrence of horizontal rhizomes was fairly restricted to the layer between 20 and 40 cm. The thick roots were remarkably long and poor in fine roots. Some thick roots were cut off at 100 cm. It was evident that many of the thick roots penetrated the gyttja at the lower levels, where the soil was characterized by relatively higher amounts of extractable metallic cations (K, Mg, Ca). Fine roots were very frequent (dense felt) down to 20 cm. The nodes of the lowermost 10 cm of the shoots were also rich in fine roots.

Shoot density. 110—160 (records from 1959 and 1963).

Flowering time. Second to third week in Sept.

Panicle frequency. Ca. 50 %.

Further data in Tables 48—51, 53, 55.

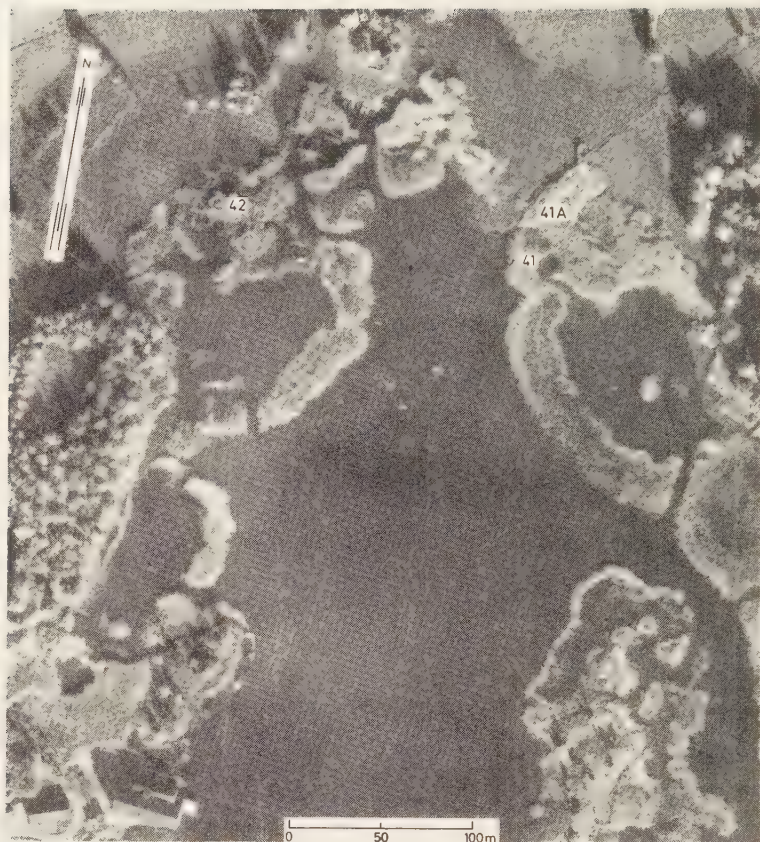


Fig. 116. Aerial photograph of the innermost part of the Pukavik bay. The location of the biotopes 41, 41 A and 42 indicated by numbers. — Photo by the Royal Swedish Air Force 621019. Published with permission of Försvarsstaben.

Pukavik

With Biotopes 41, 41 A and 42

General Description

The reed-beds in the inner part of the Pukavik bay are formed almost entirely of *Phragmites* (Fig. 116). However, immediately to the north-northwest of biotope 41 there was a *Scirpus maritimus* reed. *Typha angustifolia* occurs here and there in fairly small stands.

The *Phragmites* reed-beds occur partly along the shores and partly as seawardly expanding bow-like curved reeds, separated from the shore stands. However, also within the latter bow-like configurations were found.

The cause of the development of the bow-like formations has not yet been studied in detail. It could, however, be stated that the

Phragmites stands originate primarily from the littoral zone (cf. HÜRLIMANN 1951, pp. 31, 220 concerning the environmental requirements of the *Phragmites* seedlings which do not withstand submergence). Among those factors which obviously could be of importance for the development of the isolated reed-beds are, for example, the effects of ice, frost and waves as well as of the accumulation (e.g. through wreckage) in the reed-beds of substances, which have an unfavourable effect on the growth of *Phragmites*. The following observations seem also to be of interest in this connection.

Just to the east of biotope 42 it was noted that a shallow area without *Phragmites* at the beginning of the observation period became overgrown by this species during a period of three years. The stand of low shoots was first very sparse, but gradually it became denser and the shoots higher. Part

Fig. 117. Pukavik, seaward zone of the *Phragmites* reed-bed outside biotope 42. Floating rhizomes of a stand earlier rooted in the loose clay gyttja. — Photo S. Björk 630928.



of the area inside the long western reed-bow (Fig. 116) was for some years also overgrown by a sparse *Phragmites* stand. However, during 1963 the whole rhizome and root system, superficially anchored in the very loose clay gyttja, was lifted to the water surface (Fig. 117) where it was destroyed.

In the Pukavik area as well as commonly along the coast of Blekinge, the formation of *Phragmites* plaurs takes place. Landwards from biotope 42 *Phragmites* grew in the outer part of the shore meadow, the upper soil layer of which was peaty. In the seaward margin the stand was, due to the water level fluctuations, split up and consisted of dense clusters of shoots separated by grooves. The rhizomes and roots are originally anchored in the loose clay gyttja. However, when a sufficiently thick layer of dense *Phragmites* rhizome and root felt was developed, this light layer was lifted by the water during periods with high water level. The structure as well as the further development of the type of plaur which occurred in the area around biotope 42 are described below.

As for water level fluctuations see Figs. 74 and 111.

The habitus of the *Phragmites* shoots showed considerable variations between different clones as well as between different parts of the same clone. In the last-mentioned case the modifications are caused by, for example, differences in bottom conditions, in water depth and in the age of

separate parts of the clone. As for the occurrence of clones with different genetic constitution this was plainly demonstrated in biotopes 41 and 41 A. The dark green shoots, among other things characterized by large panicles, of the stand with biotope 41 sharply contrasted to the tall light green shoots, characterized by small panicles, of the clone with biotope 41 A. The boundary between these clones is seen in Figs. 116 and 118.

Biotope 41

A. Environment

Situation (Fig. 116). In the northern part of the eastern bowlike *Phragmites* stand in the innermost part of the Pukavik bay. The samplings were made 4—5 m inside the western margin of the stand.

Physiographic notes (Fig. 118). The biotope was exposed to winds from all directions. Wave action, though fairly weak, was noted only when the wind was from the south.

The *Phragmites* stand was pure (single individuals of *Lemna minor* were found now and then). The dry stems were regularly broken in the spring.

The water (Table 47). On observation occasions during the vegetation period in 1958—1964 the water depth varied from 4 to 70 cm. The water level



Fig. 118. Pukavik. To the right the stand with biotope 41. The high *Phragmites* stand to the left includes biotope 41 A. At the extreme left a *Scirpus maritimus* stand. Compare Fig. 116.

— Photo S. Björk 590915.

fluctuations have, however, been greater (71 cm in May—Sept. 1963 at Kungsholmen).

Due to the wind and current conditions the surface water quality was subject to great variations, which is evident from the following analyses (samplings in Aug., Oct. 1962, May, June, Aug., Sept., Oct. 1963, Aug. 1964; number of analyses in parentheses): Col 10—40, $m=20$ (5), Sp.cond. 1.0—11.7, $m=7.3$ mS (8), pH 6.7—8.7, $m=7.6$ (8), Na 6.57—101, $m=62.8$ (5), K 0.19—2.55, $m=1.57$ (6), Mg 0.64—11.7, $m=7.20$ (6), Ca 0.70—3.74, $m=2.03$ (6) mmol/l, Fe 2—3 $\mu\text{mol/l}$ (3), Cl 7.80—118, $m=70.7$ mmol/l (8), P 1.1—3.8 $\mu\text{mol/l}$ (2), Alk 1.12—1.69, $m=1.42$ meq/l (5). The lowest specific conductivity was found in spring and autumn and the highest in the summer months. In the four August and September samples the conductivity varied between 8.9 and 11.7, $m=10.4$ mS.

The bottom (Fig. 119). Within the stand there was an accumulation of decaying *Fucus vesiculosus* forming a 5 cm thick layer.

Stratigraphy:

- 0— 11 cm Very loose, black, sandy gyttja, containing shell fragments of *Macoma baltica* and *Mytilus edulis*.
- 11— 15 cm Transition layer.
- 15— 24 cm Grey, sandy gyttja, H_2S -smelling.
- 24— 29 cm Sandy gravelly transition layer.
- 29— 41 cm Dark beige sandy gyttja, here and there with pure grey sand and fine sand layers.
- 41— 54 cm Grey sand.
- 54— 71 cm Sand and gravelly sand with drift material (rich in fruits).
- 71—105 cm Loose clay; alternating grey-blue and black-grey layers. In the uppermost part with drift material.
- 105—120 cm Light grey-blue, heavy to very heavy clay.
- 120—130 cm Blue-grey, gravelly sand. In the lowermost part sand.

The complicated stratigraphy is reflected in the physical and chemical soil analyses. The presence of shell fragments in the superficial layer was responsible for the pH displacement in the AmAc extract being slightly negative. pH values a little higher than 7.00 were also obtained in the AmAc extracts of

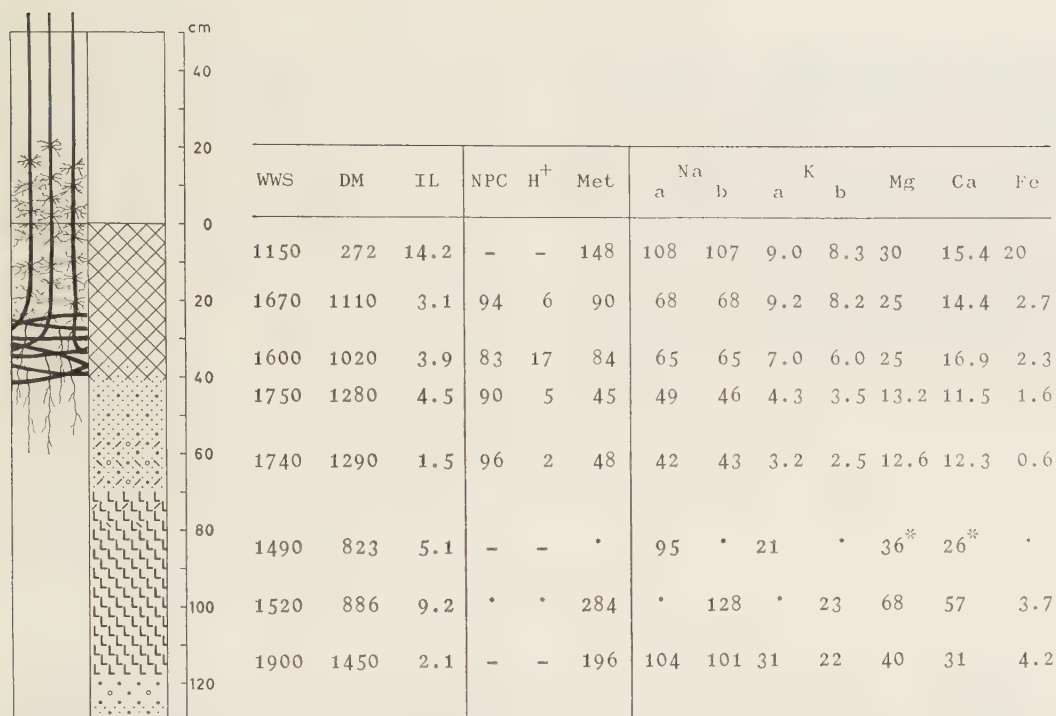


Fig. 119. Biotope 41 Pukavik 640830. Vertical section and soil analyses. *=analyses in AmAc extract.

samples from the lower layers. No CaCO_3 grains were, however, ocularly detectable in these samples. The amount of extractable metallic ions, which was fairly high in the upper black gyttja layer, became relatively low in the middle sandy part and again high in the lower clay layers. The highest values for extractable Na, K, and Mg were also found in the upper and lower layers. For Ca this type of distribution was not so evident as the values from the upper part were fairly uniform. As for Fe, there was also a minimum in the middle part.

B. *Phragmites communis*

Rhizomes and roots (Fig. 119). The horizontal rhizomes were concentrated between 25 and 40 cm. Especially between 25 and 35 cm the frequency was high. Thick roots were found down

to 60 cm. Below this level no roots at all were observed, and thus the clay layers, obviously rich in nutrients, did not seem to be available for *Phragmites*. It was characteristic of the shoots in this biotope that the lowest 2—4 nodes were richly set with fine roots.

Shoot density. Ca. 85. Densities from 65 to 115 were registered in 1959—1963.

Flowering time. In some years the dark violet panicles were entirely grown out already in the middle of Aug., but usually they were not in full flower until the second or third week in Sept.

Panicle frequency. Ca. 70 %; minimum in 1962 with 61 % (30 % of the panicles sterile or dry), maximum in 1963 with 78 % (all panicles normally developed).

Further data in Tables 48—55.



Fig. 120. The plaur biotope 42 Pukavik 620525. The dry stems broken in the rooted *Phragmites* stands (in the foreground) but on the plaurs they remain unbroken. — Photo S. Björk.

Biotope 41 A

Situation. See Figs. 116 and 118.

From this biotope only a few observations are included in order to illustrate the striking differences between the *Phragmites* clone growing in 41 A and the one in biotope 41. The reader is referred to Fig. 133 as well as to Tables 48—52. Comparisons between the biotope 41 and 41 A clones are made in the Synthetic Part. During the observation period 1959—1965 the border between the two clones moved somewhat to the north.

Biotope 42

A. Environment

Situation (Fig. 116). Western margin of the plaur area in the northwestern part of the Pukavik bay.

Physiographic survey (Fig. 120). When the first samplings were made in 1955, the samples were taken from a *Phragmites* plaur complex situated close to the shore. During the following years the different plaurs changed position in relation to each other and to the shore. Thereby the plaurs gradually, but for the most slowly, moved seawards from the shore, along which they arise. The greatest changes during the period 1955—1965 took place in the spring of 1962, when the plaur under investigation had moved ca. 10 m seawards.

In the latest years the shore meadows have been grazed intensively and during low water periods even *Phragmites* was grazed to the very shore line so that the possibilities of plaur formation and “calving” for the present are reduced.

The thickness of the plaurs was 40—50 cm. When the water depth was greater than their thickness they float with the upper surface above the water. At lower water level they rest on the bottom.

The plaur biotope was exposed to winds from all directions. Wave action was hardly noticeable.

On the plaur the dry *Phragmites* stems remained for at least two to three years. Due to the preservation of the dry stems the plaurs were easily noticeable in spring when the stems of the rooted *Phragmites* stands were broken (Fig. 120).

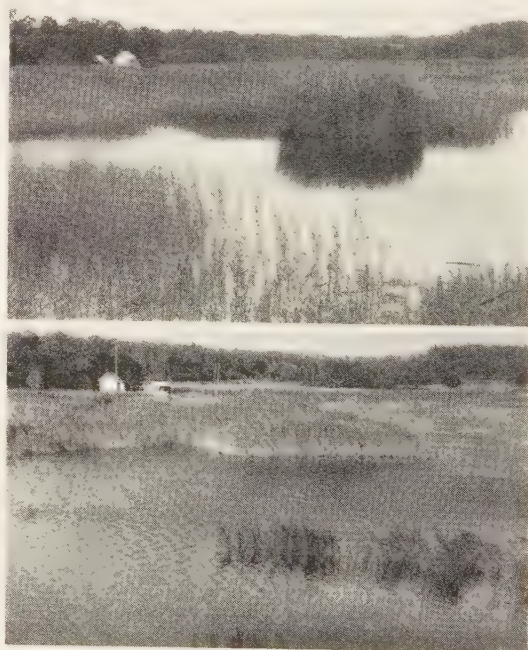


Fig. 121. Pukavik, view to NE from the cape SSW of biotope 42 (cf. Fig. 116). The photographs, taken 570919 (top) and 651001, illustrate the changes in the extension and development of the reed-beds. The plaur in the top photograph originated from the shore zone east of biotope 42. — Photo S. Björk.

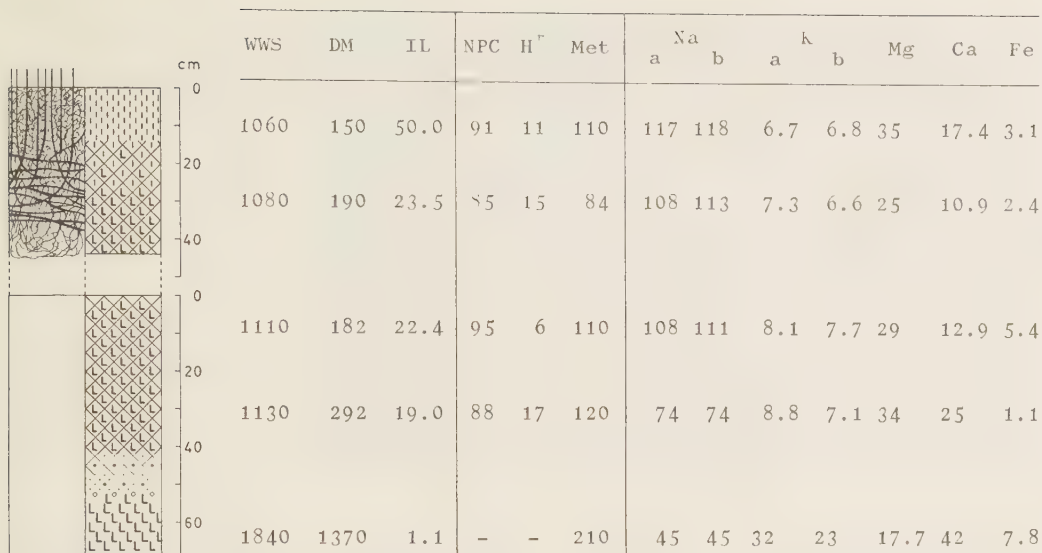


Fig. 122. Biotope 42 Pukavik 640830. Vertical section and soil analyses.

In the plaur biotope the *Phragmites* stand was quite pure. Along the margin a parafyllion was indicated by single individuals of *Aster tripolium*. In the more or less open water around the plaur there were rooted, scattered and more or less occasional stands of *Phragmites*, *Scirpus maritimus* and *Typha angustifolia*.

The water (Table 47). As for water level fluctuations see biotope 41 pp. 165—166. During the summer months the plaur was floating only for fairly short periods. On the observation occasions the water depth around it varied from 5 to 70 cm.

The variations in the water quality resembled mostly those in biotope 41. On four occasions (Aug., Oct. 1962, Sept. 1963, Aug. 1964) samples were taken at the same time in biotope 41 and 42. In three cases the specific conductivity was but slightly higher — maximum 13 % — in biotope 42 than in biotope 41. In Oct. 1962 it was, however, 2.9 mS — i.e., 57 % — higher in biotope 42 than in biotope 41. Besides the men-

tioned sampling occasions one sample was taken in Sept. 1962. Analytical data (number of analyses in parentheses): Sp.cond. 8.1—12.2, m=9.8 mS (5), pH 6.5—7.4, m=7.1 (5), Cl 78.8—123, m=97.0 mmol/l (5).

The bottom (Fig. 122). The described section was obtained on an occasion of low water level when the plaur was lying on the bottom. A core of the very dense and tough plaur was cut out with the sharp-edged Digerfeldt sampler. After the roots of the underside of the plaur had been cut off, the upper core surface was kept at the original plaur level (by holding in the basal parts of *Phragmites* shoots) as the sampler was pressed down into the loose sediments underlying the plaur. In this way a quite undisturbed core was obtained.

Stratigraphy:

Plaur

0—44 cm Rhizome and root felt, in the upper 14 cm with a dark brown filling substance of humified

Phragmites material, downwards with clayey gyttja and clay gyttja.

Sea bottom

- 0—16 cm Dark gery, very loose clay gyttja, here and there blackish. Odor of H₂S.
- 16—42 cm Dark olive-green brown clay gyttja, a little sandy. Downwards denser.
- 42—53 cm Sand, in the upper part grey-brown, with a little gyttja, downwards purer grey.
- 53—69 cm Light grey-blue heavy clay, covered by a thin gravel layer.

The difference between the uppermost and the lower part of the plaur is evident also from the weight analyses of the soil. As for neutralization percentage and cation content the clay differed markedly from the overlying, in these respects fairly uniform soils. Na decreased downwards, while K (though not so plainly in HAc extracts) increased. Extractable Mg as well as Na were markedly lower in the clay than in the clay gyttja, while Ca showed the opposite concentration condition.

B. *Phragmites communis*

Rhizomes and roots (Fig. 122). In the plaur the rhizomes and roots constituted an extremely dense and tough felt. The main part of the horizontal rhizomes occurred between 20 and 36 cm. A very interesting fact is that the bottom layer of plaurs of this kind, developed in mixohaline environment with fluctuating water level, is made up of a pure root felt without any filling substance. In Pukavik the roots in this layer were closely pressed against the plaur, thus giving this a fairly smooth underside. No roots grew downwards in the bottom clay gyttja.

Probably this arrangement of the roots is caused by the plaur being alternately floating and resting on the bottom. No living *Phragmites* rhizomes or roots were found in the sediments under the plaur. However, dead *Phragmites* rhizomes were found down to 45 cm. Roots on the lower stem nodes were very rare.

Shoot density. Ca. 85.

Flowering time. Second to third week in Sept.

Panicle frequency. Ca. 10 % (in 1961 20 %, all panicles well developed; in 1962 5 %, all panicles sterile or dry).

Pollen morphology (note). It was characteristic of the pollen of this clone that the frequency of elongated grains was rather high.

Further data in Tables 48—53, 55.

Lödösnäs

With Biotopes 43—44

General Description

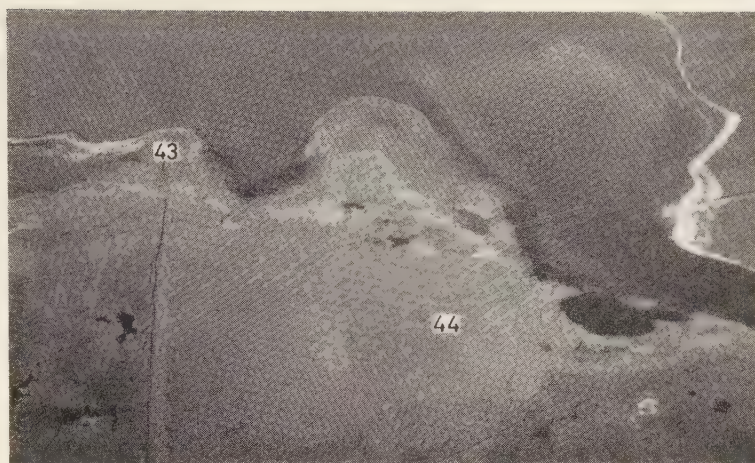
The investigated area is shown in the aerial photograph in Fig. 123. On both sides of a simple embankment built out to a little island situated ca. 300 m from the shore line, large *Phragmites* stands have developed in shallow water. The embankment is situated ca. 400 m south of the mouth of the river Kävlingeån in the Sound. Two biotopes are described from Lödösnäs. Both were exposed to winds from all directions. As for water level fluctuations compare the diagram for Ystad (situated ca. 70 km along the coast SE of Lödösnäs) in Fig. 111.

Biotope 43

A. Environment

Situation (Figs. 4 and 123). About 3 m from the reed-bed margin in the bay (cf. below) and ca. 12 m inside the reed-bed

Fig. 123. Aerial photograph of the *Phragmites* reed-beds at Lödösnäs. The location of the biotopes 43 and 44 indicated by numbers. To the right the mouth of the river Kävlingeån. The bay mentioned in the text to biotope 43 is seen immediately to the left (south) of the biotope. — Photo Stenbergs Bilder 650601. Stenbergs Bilder 650601. Published with permission of Försvarsstaben.



margin on the island, i.e., ca. 20 m from the sea shore line.

Physiographic survey (Fig. 124). On the landward side of the island south of the embankment there is a shallow bay which is partly overgrown by *Phragmites* and in landward parts also to some extent by *Typha angustifolia*. At high water level and strong westerly to southerly winds the island is washed by the waves and masses of seaweed are collected in the bay. On such occasions, which mostly take place in autumn and winter, the outer part of the reed-bed is also washed by the waves and the wreckage (algae etc.) is piled up in walls within the *Phragmites* stand, sometimes as much as ca. 70 m from its seaward margin.

In the biotope the *Phragmites* stand was quite pure. In 1963, the year of the most intensive investigations here, ca. 30 % of the dry *Phragmites* stems from 1962 remained unbroken until the autumn.

The water [Table 47, Fig. 139 (day series)]. The specific conductivity of the surface water at the margin of the stand (3 m outside the sampling site in the biotope) varied from 3.5 to 10.8 mS according to determinations made in 1963. In the surface water in the biotope the conductivity varied from 3.8 to 10.7 and in the interstitial water (from a dug pit) from 7.7 to 10.4 mS.

The rapidly occurring changes in the quality of the water in the bay are, among other things, due to the proximity to the mouth of the river Kävlingeån. Now and then *Lemna minor* and *Spirodela polyrrhiza* were transported with the river water to the biotope. These plants, however, soon died in this environment.

Interstitial water was also obtained by suction of fresh soil samples taken in the core described below. The analytical data indicated that the concentration of Na in the interstitial water was about the same as the concentration which could be calculated on the basis of water content and extractable Na concerning the whole soil at the respective levels. Thus it could be stated that Na extracted from whole soil in this case was derived from the interstitial water. As for K greater amounts were extracted than obtained in the interstitial water and concerning Mg and Ca this difference was considerably greater.

In the interstitial water there was a minimum with respect to specific conductivity, Na, K, Mg, and Cl at 40 cm. The values for pH increased downwards.



Fig. 124. Biotope 43 Löd-
desnäs. In the foreground
the inner part of the bay
mentioned in the text. —
Photo S. Björk 660828.

The concentration of Ca was fairly even throughout and as for Fe the highest value was obtained from the 40 cm level.

The bottom (Fig. 125). The surface was either bare gyttja or covered by a thin layer of coarse *Phragmites* detritus.

Stratigraphy:

- 0— 20 cm Brown gyttja. Very dense felt of fine *Phragmites* roots.
- 20— 63 cm Black-grey, loose gyttja, in the lower part with mollusk shells (e.g. *Hydrobia*).
- 63— 85 cm Black-grey, sandy gyttja rich in mollusk shells.
- 85—105 cm Grey, somewhat sandy, clay gyttja, rich in mollusk shells.
- 105—119 cm Light grey, slightly sandy clay, rich in CaCO_3 grains.
- 119—124 cm Light grey, somewhat clayey sand.

With respect to the redox potential and pH the uppermost gyttja differed markedly from the underlying gyttja layers in which the redox potential was considerably lower and the pH higher. In connection with the appearance of CaCO_3 particles there was a further rise in the pH. The amount of extractable metallic cations increased downwards. In the gyttja soils the content of extrac-

table Na was fairly even throughout. There was a slight trend for K to increase downwards in these soils. Above the shell-bearing soils the downward increase in the concentration of Ca was moderate, but from these high values were obtained and the clay was very calcareous. With the exception of the superficial layer which was characterized by comparatively low values, the amounts of extractable Fe and P were rather uniform in the underlying soils.

B. *Phragmites communis*

Rhizomes and roots (Fig. 125). Horizontal rhizomes were observed from 20 to 55 cm (below this level only single dead rhizomes were found), with the highest frequency in the middle part. Neither thick nor fine roots seemed to reach the calcareous clay. Down to 20 cm there was a tough, dense felt of fine roots. The lowermost shoot nodes were very seldom provided with roots.

Shoot density. 75—100 (1963).

Flowering time. First to second week in Sept.

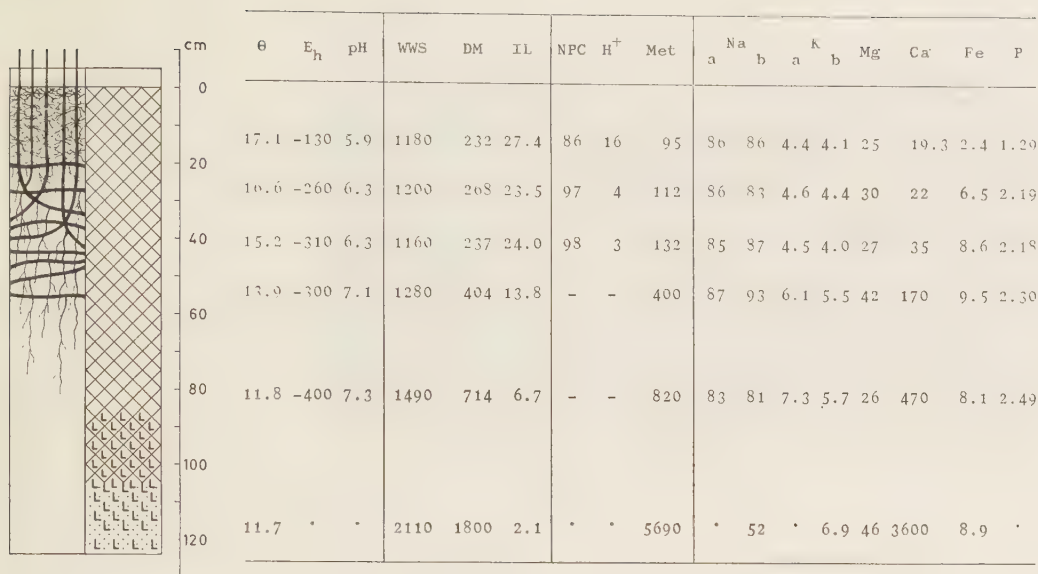


Fig. 125. Biotope 43 Lödösnäs 630726. Vertical section and soil analyses.

Panicle frequency. 75 % (1963).

Further data in Tables 48—51, 53, 55 and in Figs. 139—140 (day series).

Biotope 44

A. Environment

Situation (Fig. 123). In the landward part of the reed-bed, ca. 110 m seawards from the original shore line.

Physiographic survey (Fig. 126). Also in this biotope there was an alternation between emergence and submergence. However, the time quotient between these conditions is greater here than in biotope 43. Biotope 44 is never washed by the waves.

A sparse intermingling of other plant species occurred. Among these *Myosotis palustris* and *Calystegia sepium* were most common. The other noted species, represented by single individuals, were *Caltha palustris*, *Lysimachia thyrsiflora*, and *Solanum dulcamara*.

The dry *Phragmites* stems remained unbroken for at least one vegetation period. In 1963 there were twice as many dry as green shoots.

The water (Table 47). All water samples except one were taken in dug pits. The specific conductivity of the water from the superficial soil layer varied on the sampling occasions in May—Dec. 1963 from 1.9 to 4.2 mS. At the end of Sept. the biotope was submerged. Judging from the analytical data the main part of this water originated from Kävlingeån. Occasionally the biotope is submerged by sea water.

The bottom (Fig. 127). This biotope offers an illustrative example of the changes which can take place in the bottom conditions as a result of the prolonged occurrence of *Phragmites*.

Stratigraphy:

0—38 cm *Phragmites* root felt with some gyttja, the upper part dark brown, the lower part grey-brown.

38—78 cm Light grey heavy clay, with some gravel, sand, and silt and rich in flint stones. From 60 cm varved clay.



Fig. 126. Biotope 44 Löd-
desnäs. — Photo S. Björk
660828.

78—90 cm Blue-grey to grey, very heavy
clay.

90—95 cm Clay, fine sandy and silty.

The limit between the root felt and the underlying minerogenic soils was very distinct. As for the redox potential, low values were obtained in the root felt layer, but especially low in the upper part of the minerogenic soil, which was rich in very ill-smelling dead rhizomes. In the lower half of the root felt layer the presence of small shell fragments was probably responsible for the weakly negative pH displacement in the AmAc extract. The minerogenic soils were calcareous, which was evident from the high figures for extractable metallic cations. The amount of extractable Na increased downwards, especially in the lower layers of minerogenic soils. The sharp limit between the organogenic soil and the clay was also registered in the values for extractable K, Mg, Fe, and Ca.

B. *Phragmites communis*

Rhizomes and roots (Fig. 127). The living horizontal rhizomes were mainly concentrated between 7 and 20 cm, but occurred also somewhat deeper. Living fine roots were observed down

to ca. 65 cm and occurred as a very dense felt in the upper part of the organogenic layer. Very rarely fine roots occurred on the lowermost stem nodes.

Dead horizontal rhizomes were very frequent in the lower part of the root felt layer, but also in the upper part of the underlying minerogenic soils. The lower limit for dead rhizomes was situated at ca. 60 cm. Thick dead roots penetrated the heavy clay down to 90 cm and fine roots occurred also below this layer. It is characteristic of this biotope as well as of other similar biotopes situated in more or less mixo-haline environment that the dead rhizomes have an obnoxious odor, resembling that of sulphite lye.

Through the formation of the root felt layer the soil surface has been raised 38 cm in the biotope. The vertical extent of the present rhizosphere seems to be about the same as that characteristic of *Phragmites* growing here before the root felt layer was developed, viz., ca. 55—65 cm. However, due to the formation of the 38 cm thick organogenic layer, the roots of the present stand do not seem to be able to reach the layer of heavy clay, in which dead *Phragmites* roots

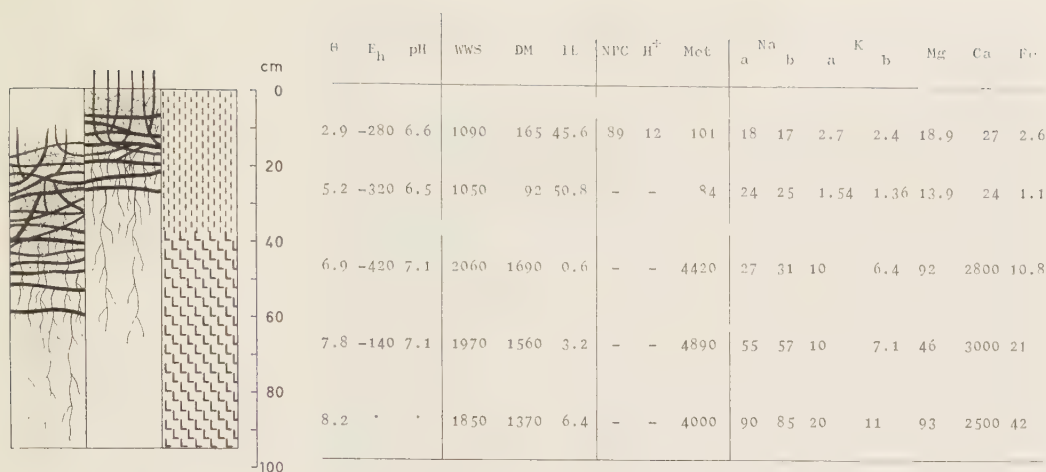


Fig. 127. Biotope 44 Lödösnäs 631210. Vertical section and soil analyses. The left section illustrates the approximate distribution of dead rhizomes and roots, the middle one the extension of the present rhizosphere.

were found. In other words, the whole stand has been lifted.

Shoot density. 75—110 (1963).

Flowering time. The panicles were grown out already in the first week in Aug. and were in full flower in the last week in Aug. (1963—1966).

Panicle frequency. 90 % (1963).

Further data in Tables 48—51, 53, 55.

Björred

With Biotopes 45 A—C

A. Environment

Situation (Fig. 4). From the outer part of a low peninsula, totally overgrown by *Phragmites*, observations were made in a series of three biotopes, situated close together. These were located along a N—S line perpendicular to the shore, viz., 45 A on the middle, highest part of the peninsula, 45 B in the littoral zone, and 45 C in the seaward, southern margin of the *Phragmites* stand. (The distance — along the line — between the biotopes was ca. 5 m.)

Physiographic survey (Fig. 128). The direction of the shore line is east—west. The biotopes were exposed to winds from

the south, west and north. The wave action could be strong in the biotopes 45 B—C, especially when the wind is from the south-west. At high water and with strong motion of the sea the whole peninsula was washed and the *Phragmites* shoots broken. As a rule no dry stems remained for the next vegetation period. There was no intermingling of other macrophytes in the biotopes, but stands of *Scirpus maritimus* and *Typha angustifolia* occurred in the vicinity.

The water (Table 47). As for water level fluctuations see the diagram for Ystad in Fig. 111.

In 45 A the specific conductivity in the two available samples of interstitial water (sampled in dug pits) was 5.4 and 10.5 mS.

In 45 B surface water was sampled in a depression in the bottom. In a sample from Aug. 1962 the specific conductivity was 5.2 mS, but during the period Sept.—Nov. 1962 values from 23 to 14 mS were obtained. Low values were recorded from June and Oct. 1963, while an intermediate value was obtained in July.

Biotope 45 C was characterized by *Phragmites* growing in tussocks with a height of ca. 35 cm above the minero-



Fig. 128. Bjärred. The section with biotopes 45 A—C located in the outer part of the peninsula. Direction from right to left. — Photo S. Björk 660829.

genic bottom. Between the tussocks the bottom (heavy clay covered by sand) was without vegetation. The highest conductivity value recorded for the water outside the tussock was 14.1 mS, viz., in Nov. 1962. From May to Oct. 1963 values varying from 2.8 to 10.4 mS were obtained. Great differences in the water quality were established between the water outside and the water inside (sampled in small pits at low water level) the tussock. The distance between the sampling sites outside and inside the tussock was 30 cm. In May 1963 the water outside the tussock had the highest conductivity, viz., 10.2 mS, while the value for the water inside it was 6.6 mS. In June 1963 the reverse conditions occurred, i.e., the lowest conductivity, 2.8 mS, was found outside and the highest, 7.3 mS, inside the tussock.

On the whole the variations in the water quality are great and can occur rapidly within this shore reach of the Sound. Though not thoroughly investigated it seems, however, that the water within the *Phragmites* tussocks has a more stable quality.

The bottom.

Biotope 45 A: 25 cm gravelly sand (very rich in mollusk shells) covering blue grey heavy clay.

Biotope 45 B: The stratigraphy was intermediate between 45 A and 45 C, i.e., a thin *Phragmites* root felt was developed. Beneath this was a layer of sand and then one of clay. The root felt was not even, but higher parts alternated with depressions that were fairly free from *Phragmites* shoots.

Biotope 45 C: 35 cm *Phragmites* root felt, downwards followed by a blue-grey clayey sand layer which constituted the transition to the underlying clay.

B. *Phragmites communis*

Rhizomes and roots. In 45 A the highest frequency of horizontal rhizomes occurred in the lower part of the gravelly sand overlying the clay. No determinations of the vertical extent of the rhizosphere were made. However, in all three biotopes the clay was available to the roots.

Shoot density. In 45 A ca. 130

Fig. 129. Praestö Fjord. Biotope 46 to the left, in the middle zone of the reed-bed. — Photo S. Björk 660912.



(+40 DS), in 45 B ca. 260 (+240 DS), and in 45 C ca. 720 (+400 DS).

Flowering time. In 45 A about the middle of Sept., and in 45 C ca. two weeks later.

Panicle frequency. In 45 A ca. 60, in 45 B ca. 30, and in 45 C ca. 20 %.

Further data in Tables 48—52, 55.

Praestö Fjord

With Biotope 46

General Description

During the first years of the 1940's Praestö Fjord was subjected to combined geographic, geologic, and biologic investigations. The bottom deposits are described by HANSEN (1944), the hydrographic conditions by JENSEN (1944), and the spermatophyte and charophyte vegetation by OLSEN (1945). On the basis of the descriptions of *Phragmites* stands given by OLSEN (op.c.) as well as of personal information from him, a biotope was chosen in the stands with very high shoot densities, which are characteristic of the southwestern part of Praestö Fjord.

Biotope 46

A. Environment

Situation (Fig. 4). Outside the beech forest "Hollenderskov", approximately where the sampling station no. 65 according to OLSEN (op. c.) was located, ca. 10 m inside the seaward margin.

Physiographic survey (Fig. 129). Landwards from the biotope the broad reed-belt was followed by an earlier grazed meadow and then by the beech forest. However, when the grazing was discontinued, the meadow was overgrown by tall *Phragmites* shoots and in 1966 no open areas remained.

The biotope was exposed to eastern winds. The wave action was moderate.

In the biotope the *Phragmites* stand was pure. Landwards there was an intermingling with *Scirpus maritimus*. No dry *Phragmites* stems from the preceding vegetation period occurred in the zone where the biotope was situated.

The water (Table 47). As for water level fluctuations see JENSEN (op. c.), who describes the occurrence of sudden changes in the water level which are due to the force and direction of the winds.

The specific conductivity of the sur-

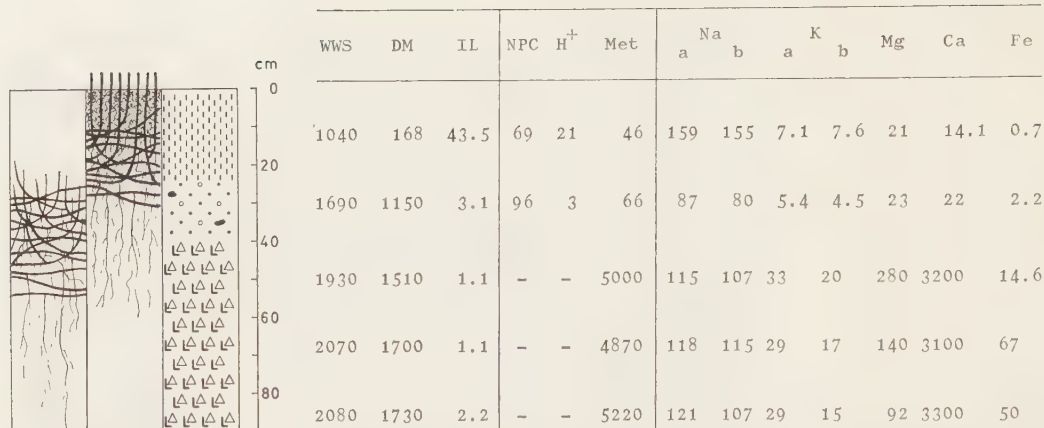


Fig. 130. Biotope 46 Praestö Fjord 640824. Vertical section and soil analyses. The left section illustrates the approximate distribution of dead rhizomes and roots, the middle one the extension of the present rhizosphere.

face water seemed to be higher here than in the Swedish coast biotopes in Scania and Blekinge. According to JENSEN (op.c.) the salinity of the Praestö Fjord water is about 7.5 to 9.0 ‰, but sometimes there is an influx of more saline water and the salinity can occasionally rise to 12—13 ‰ in the northern part of the fjord.

The bottom (Fig. 130). The surface consisted of the bare dense *Phragmites* root felt. Filamentous algae, especially *Enteromorpha*, were common.

Stratigraphy:

- 0—24 cm Very dense root and rhizome felt of *Phragmites*. The upper 12 cm consisted mostly of fine roots. Downwards rhizomes and thick and fine roots made up the felt. A little sand and detritus was intermingled but the proportion was insignificant.
- 24—39 cm Beige-brown to dark grey, gravelly sand with small stones and small mollusk shell fragments. Rich in ill-smelling dead *Phragmites* rhizomes.
- 39—58 cm Blue-grey, fairly loose, moraine clay. Rich in ill-smelling *Phragmites* rhizomes.
- 58—90 cm Hard, heavy moraine clay, down-

wards gradually harder. Rich in chalk grains. Black portions here and there.

The sandy and somewhat stony layer under the root felt represented the former, washed bottom surface layer. The amounts of extractable metallic cations from the two upper layers were relatively small. The clayey soils were decidedly calcareous.

If all Na is assumed to be in solution in the water lost when drying the soil samples at 105°C, the concentrations at all sampled levels were higher than in the sea water on the sampling occasion. Compared with the concentration in the sea water the concentrations at the five sampled levels were, in a downward direction, 133, 112, 195, 232, and 238 ‰.

As for extractable K, Mg, Ca, and Fe there was a great difference between the clay and the overlying soils. The large amount of extractable Fe from the heavy clay may be noted.

B. *Phragmites communis*

Rhizomes and roots (Fig. 130). The living horizontal rhizomes were in

the main concentrated between 10 and 30 cm. Fine roots emanating from thick ones were found down to the hard heavy clay. From 0 to 12 cm there was a nearly pure felt of fine roots. Very rarely fine roots occurred on the lowermost stem nodes.

Dead horizontal rhizomes and basal parts of vertical rhizomes occurred down to 55 cm. The frequency was high at 50 cm and increased upwards. Dead fine roots were observed in the lower part of the hard heavy clay.

Judging from the observations on the occurrence of living and dead rhizomes and roots it can be stated that the rhizosphere of the present stand has about the same vertical extent as that characteristic of the stand before the root felt layer was developed. As a result of the elevation of the bottom level the *Phragmites* stand has been lifted, but the clay underlying the washed sandy layer is still available to the roots.

Shoot density. As pointed out by OLSEN (1945) the shoot density is here remarkably high. For the sampling stations 65 and 66 the shoot densities 518 and 469 are given (OLSEN op.c., Table 2). The samplings carried out by OLSEN were made in Aug. 1941 and 1943.

In biotope 46 the density of shoots with green leaves was 178 on Sept. 1, 1963. However, the examined square also contained 218 dry small shoots belonging to a shoot generation developed later in the vegetation period than the higher shoots which were in very good condition at the time of the sampling (developed panicles but only single panicles flowering). The total number of shoots thus amounted to 396. In 1964 the proportions of dry and growing shoots were the same, but in 1966 the percent-

age of dry shoots was considerably lower at the corresponding time.

The observations in 1963—1964 indicated that in the landward and seaward zones of the reed-bed the shoot densities were lower at the same time as the shoots were markedly higher. At the flowering time there were no dry shoots in either of these zones. In the middle zone (with biotope 46) the shoots were low. The other characteristic features were the high shoot density and the great number of dry shoots. Thus, if a curve illustrating the shoot height in the zones is drawn perpendicular to the shore, a concave curve is obtained.

Judging from the successive transitions between the different zones within this special reach, the reed-bed is from land to sea made up of one single clone and the differences with respect to shoot density etc. are due to environmental conditions. In the middle zone the elevated root felt must be fairly exposed to injury, especially during the winter and early spring, in connection with alternations of the water level. In any case, in some years a great number of buds are stimulated to development. However, as has been shown, a great number of shoots dry early during the vegetation period. In the marginal zones where the soil surface is fairly permanently emerged (landward margin) and submerged (seaward margin), the environmental conditions are more stable. Therefore the young shoots, already somewhat grown out in the autumn, do not seem to be destroyed, and thus latent buds are not stimulated to development in early summer the following year.

In 1966 the shoot height was more even throughout the reed-bed than in 1963—1964.



Fig. 131. Biotope 47 Ängen.
— Photo S. Björk 620804.

Flowering time. In 1963, 1964 and 1966 the panicles were in full flower in the second week in Sept.

Panicle frequency. Ca. 60 % (only 30 % if the number of shoots with panicles is put in relation to the sum of dry and green shoots developed in 1963 and 1964).

Further data in Tables 48—51, 53, 55.

Ängen

With Biotope 47

A. Environment

Situation (Fig. 4). Immediately north of the town Varberg, on the southern side of a small peninsula (Näsboudd), southwest of Ängen.

Physiographic survey (Fig. 131). The *Phragmites* stand grew in a little creek between projecting, low, rounded rocks. Northwest of the stand there was a fairly high, rounded rock. The shore line has an east-west direction. The biotope was exposed to southerly winds. The wave action could be fairly strong, especially when the

wind had a southwesterly direction. The shoots were then washed by the waves and wreckage piled up over bent-down shoots in the inner zone of the reed-bed.

The *Phragmites* stand was quite pure. The dry stems were broken in winter or spring.

The water (Table 47). As for water level fluctuations see the diagram for Varberg in Fig. 111. In 1962 the difference between the recorded highest and lowest levels at Varberg was 97 cm and in 1963 126 cm during the period May—Sept. According to GILLNER (1960, p. 18) the difference in water level between ebb and flood is 15 cm at Varberg at the times for new and full moon.

As pointed out by GILLNER (op.c.) the quality of the water along the Swedish west coast is subject to great changes. In biotope 47 the specific conductivity on one occasion in Aug. 1962 was 17.6 mS, in Aug. 1963 4.3, and in Sept. 1966 22.6 mS.

The bottom (Table 46). At least down to 50 cm the bottom consisted of sand and silty sand, here and there stony (a stainless steel tube could not be forced down more than 50 cm).

Fig. 132. Biotope 48 Hakenäs. — Photo S. Björk 630821.



In a soil sample from 10 cm the presence of mollusk shell fragments caused a slight rise in the pH of the AmAc extract. The low content of Na (9.6 mmol/l whole soil) may be explained partly by the fact that the sample was taken superficially during a period of strong dilution of the sea water and partly by the assumption that there is a supply of fresh subsoil water to the sandy layer from the slope above the biotope. (In another soil sample, taken from about the same level in another part of the stand, the amount of extractable Na was 16.8 mmol/l.) The low contents of K and Mg may be explained in the same way. The presence of mollusc shells was, of course, responsible for the high content of Ca.

B. *Phragmites communis*

Shoot density. Ca. 250.

Flowering time. Third to fourth week in Aug.

Panicle frequency. Ca. 75 %.

Further data in Tables 48—52, 55.

Hakenäs

With Biotope 48

A. Environment

Situation (Fig. 4). In the inner part of the Hake Fjord, inside the island of Tjörn.

Physiographic survey (Fig. 132). The ground above the shore line (NNW—SSE direction) was partly grassed and partly overgrown with a curtain of *Alnus glutinosa*, *Populus tremula*, and *Sorbus intermedia*, weakly wind-trained from the south.

The biotope was exposed to westerly and especially to southerly winds. With strong southerly winds the wave action was considerable, the *Phragmites* shoots were washed by the waves and wreckage piled up over the bent-down shoots in the landward zone of the reed-bed.

The stand was pure. The dry stems were regularly broken during the winter or spring.

About 100 m to the north-northwest of the biotope there was a dwelling-house sewage discharge, causing a marked local increase in the quantitative development of *Phragmites*.

The water (Table 47). As for water level fluctuations see the diagram for Smögen (situated 50 km NW of Hake-

Table 46. Soil analyses from biotope 47 Ängen 630820 and 48 Hakenäs 630821.

Bio- tope	Level cm	WWS	DM	IL	NPC	H ⁺	Met	Na		K		Mg	Ca	Fe
								a	b	a	b			
47	10	2000	1580	0.8	—	—	89	.	9.60	.	1.92	6.5	42	3.3
48	8	1910	1490	0.8	—	—	140	105	121	5.92	6.93	19	78	3.1
	25	1970	1490	2.5	—	—	453	185	186	38.9	27.8	82	160	23

näs) in Fig. 111. In 1962 the greatest difference between highest and lowest sea level recorded at Smögen during the period May—Sept. was 120 cm and in 1963 130 cm. The difference between ebb and flood is ca. 30 cm at the times for new and full moon (GILLNER 1960, p. 18).

On Aug. 21, 1963, the specific conductivity of the surface water was 27.8 mS, i.e., the highest recorded for all biotopes dealt with in this paper. On Sept. 8, 1966, it was 25.5 mS. The salinity off the coast of the middle part of Bohuslän is 28—30 ‰ (GILLNER 1960, p. 21). Along the coast the salinity of the surface water is, however, subject to great and rapid changes, especially in the bays and near the shore (cf. GILLNER op.c.).

With strong winds the water became turbid from clay in the bay with biotope 48.

The bottom (Table 46).

Stratigraphy:

0—10 cm Somewhat silty sand, here and there intermingled with black organogenic matter and with shell fragments of *Cardium* and *Mytilus*.

10—20 cm Clayey sand.

20—100 cm Grey-brown very heavy clay.

The presence of mollusc shells in the superficial layer caused a rise in the pH of the AmAc extract. Also the heavy clay

was calcareous. If the Na content of the superficial soil is put in relation to the water content determined by drying the soil at 105°C and all Na is assumed to be dissolved in this water, the concentration of Na in this is about the same as in the sea water in the biotope on the sampling occasion. If the same comparison is made concerning the clay at 25 cm, the Na concentration would be ca. 47 ‰ higher in the interstitial water than in the sea water.

With respect to the extractable amounts of K, Mg, Ca, and Fe the difference between the surface silty sand and the heavy clay was striking. Especially the K content was high in the clay.

B. *Phragmites communis*

Rhizomes and roots. The horizontal rhizomes were most frequent between 20 and 30 cm. From 0 to 10 cm a very dense felt of fine roots was developed and fine roots occurred down to at least 100 cm. Very rarely fine roots were found on the lowermost shoot nodes.

Shoot density. Ca. 140.

Flowering time. In the third to fourth week in Aug.

Panicle frequency. Ca. 40 ‰.

Further data in Tables 48—52, 55.

Survey of the Analyses

In the sea outside the coast of South Sweden and adjacent parts of Denmark there is a marked salinity gradient through the Sound from northeast to northwest (Fig. 109). Within the investigation region the lowest salinity values are found in the east, outside Blekinge, and the highest in the northwest, outside Bohuslän. However, due to the dilution with fresh water from the rivers and to wind conditions the salinity in the coastal biotopes is highly variable (poikilohaline waters). Occasionally, therefore, the salinity in the biotopes in Halland could be lower than in the Blekinge biotopes at the same time.

The greatest and most rapidly occurring water level fluctuations are caused by the wind. In comparison with these the regular fluctuations during the year as well as those caused by the tide are small.

On the whole with respect to the water, the environmental conditions in the coastal biotopes could be characterized as being much more labile than in the freshwater biotopes. Though there are strong variations in the salinity of the surface water in the coastal biotopes, there is, also when the lowest registered values are taken into consideration, a definite salinity difference between all the coastal biotopes and the inland water biotopes treated in this paper.

Like the group of biotopes from eutrophic regions the group of coastal biotopes in different respects is a heterogenic one. Thus there are, for example, considerable climatic differences between the regions within the southernmost and the northernmost biotopes. However, for illustrating the variation in *Phragmites*

and its environment this is rather an advantage than a disadvantage.

A. Environment

The *Phragmites communis* stands were not intermingled with other macrophytes except in biotope 44 Lödösnäs, where *Calystegia sepium*, *Caltha palustris*, *Lysimachia thyrsiflora*, *Myosotis palustris*, and *Solanum dulcamara* occurred. In the surroundings of other biotopes *Aster tripolium*, *Scirpus maritimus*, and *Typha angustifolia* were frequent.

All biotopes were situated in shallow water and most of them were more or less occasionally emerged. As the lowest water level occurs in spring and early summer, the variations in water colour were insignificant for the development of the *Phragmites* shoots.

The quality of the surface water was besides the exchange of water of different origin and composition also evidently influenced — at low water and interrupted water exchange — by the metabolic processes in the bottom. The frequency of the changes in the concentration of different elements and the amplitude of these changes were dependent on the local physiographic conditions and, as for example in the Pukavik area, considerable differences of limited extent were found in the patterns of variation.

The lowest specific conductivity of surface water, 1.0 mS, was obtained in 41 Pukavik and the highest, 27.8 mS, in 48 Hakenäs (Table 47). In the Pukavik biotope the conductivity can, however, rise to ca. 12.0 mS.

In most biotopes the reaction of the water was as a rule alkaline and pH values between 8 and 9 were frequently obtained. pH values somewhat lower than 7.0 were found in dense, over-shadowing reed-beds in the Pukavik biotopes when the influx of fresh water had been strong or the shallow water had been stagnant for some time within the reed-bed or between plaurs which were aground.

The variations registered in the specific conductivity were also reflected in the analyses of Na, K, Mg, and Cl. In comparison with these the variations in the Ca content were small. The content of total P seemed to be dependent, among other things, on the duration of the stagnation time of the water within the reed-bed, the water depth during this time and the quality of the bottom. In shallow water stagnant over decaying seaweed higher values were as a rule found than in deeper water, recently renewed from the sea, in the same biotope. In some cases also the pollution of the coastal waters was probably the cause of the occasionally high P values in a biotope.

While there is in the surface water of the coastal biotopes a continuous interaction of fresh water from the rivers and salt water from the sea, an interaction between fresh subsoil water supplied from the land and sea water penetrating from the surface or preserved in the sediment could be expected in regard to the interstitial water (analyses in Table 47).

The analyses of interstitial water from a vertical section in 43 Lödösnäs (Fig. 125) did not indicate a supply of fresh subsoil water to any of the soil layers

within the *Phragmites* rhizosphere. The salinity of the interstitial water in all layers was somewhat higher than that found in the surface water. As the biotope was situated rather a long distance off shore and the soils were clay and gyttja with low permeability, a supply of fresh water to the biotope could also, *a priori*, be doubted.

In biotopes with stratigraphic conditions like those in 46 Praestö Fjord (Fig. 130) — where a coarse minerogenic layer (with high permeability) occurs between overlying organogenic soil and underlying clay — it may be possible that the *Phragmites* rhizosphere is divided into layers with different salinity of the interstitial water. See also 47 Ängen (p. 181).

The bottom analyses are exemplified in Figs. 115, 119, 122, 125, 127, 130 and in Table 46.

In all analysed biotopes except 48 Hakenäs as low amounts of extractable metallic cations as 50—100 meq/l were found in one or more layers of *Phragmites* root felt, sand and gyttja. In other layers without or with but few CaCO_3 particles the corresponding values amounted to ca. 100—150 meq/l in gyttja in 40 Orrekulle, 41—42 Pukavik, and 43 Lödösnäs and to ca. 200—300 meq/l in clay in 41—42 Pukavik. The presence of mollusk shell fragments and other CaCO_3 particles caused high to very high values for gyttja and clay, especially in the Scanian and Zealandian biotopes 43—44 Lödösnäs and 46 Praestö Fjord.

The percentage of neutralization usually amounted to 90 and upwards and only one value lower than 80 was ob-

tained, viz., 69 % in the emerged *Phragmites* root felt in 46 Praestö Fjord.

In 40 Orrekulle and in 41—42 Pukavik (including the plaur) the highest amount of extractable Na was found in the superficial soil layer, viz., ca. 100 mmol/l. In the two first-mentioned biotopes there was, however, after a minimum again an increase downwards. In 43 Lödösnäs the extractable amount, 80—90 mmol/l, was about the same throughout the gyttja soils and about equivalent to the concentration in the lowest sampled level in 44 Lödösnäs where the upper layers had much lower values. The highest amounts of extractable Na among all biotopes, ca. 160—185 mmol/l, were found in 46 Praestö Fjord and 48 Hakenäs, and the lowest, ca. 10 mmol/l, in 47 Ängen. Probably the layer sampled in Ängen as well as the layer at 30 cm in Praestö Fjord were washed to some degree by the supply of fresh water.

As for K, the greatest concentration differences were found between soils rich and soils poor in clay. In the clay layers in 41—42 Pukavik, 44 Lödösnäs, 46 Praestö Fjord, and 48 Hakenäs the amount of K was about 10—40 mmol/l (AmAc), while the other soils had less than 10 but in no case lower than 1 mmol/l.

With the exception of sand and clay layers the content of extractable Mg was mostly of the order of 20—40 mmol/l. Lower amounts were found in sand and higher in clay. The values from the clay in 46 Praestö Fjord were the highest, up to 280 mmol/l.

A Ca/Mg quotient < 1 was characteristic of most of the soils without CaCO_3 . Here it should be recalled that the Mg and Ca analyses were made in HAC

extracts and that CaCO_3 particles (mollusk shells, chalk grains) were found in one or more sampled layers in all biotopes except 40 and 42.

Comparatively low amounts of Ca, 10—20 mmol/l, were extractable from the Blekinge biotopes 40—42, but in the described soil sections there was an increase in the lowest sampled layers. The superficial gyttja and *Phragmites* root felt in 43—44 Lödösnäs and 46 Praestö Fjord contained from 14—35 mmol/l. Very high figures for extractable Ca were obtained from the calcareous soils in the Scanian and Zealandian biotopes, viz., up to about 3600 mmol/l.

The amounts of extractable Fe were high, especially in the clay in 44 Lödösnäs, 46 Praestö Fjord and 48 Hakenäs.

B. *Phragmites communis*

The polyploid level of all investigated *Phragmites* clones was tetraploid (Table 48).

In four out of seven analysed clones the percentage of apparently morphologically good pollen was about 90. The lowest obtained value, from 45 A Bjärred, was 33 % (Table 48).

Only in biotope 42 Pukavik was the mean pollen diameter (the greatest diameter of the grains always measured) as large as about 30 μm . However, in this biotope the *Phragmites* clone was characterized by having not spheric but somewhat elongated pollen grains. Therefore the figures for diameter and volume given in Table 49 are a little too high.

The rhizosphere had in most biotopes a vertical extension not exceeding 100 cm. Due to the growth of the *Phragmites* stands in 44 Lödösnäs and 46 Praestö Fjord there has been an eleva-

tion in the bottom as well as in the whole rhizosphere (Figs. 127 and 130). Biotope 42 is representative of the plaur formations which are common in, for example, the bays along the coast of Blekinge.

The lowest panicle shoots, of the order of 200—225 cm, grew in clay in the biotopes 44—48 in the Sound and on the west coast of Sweden (Table 51). In the Blekinge biotopes 40—42 and in 43 Lödösnäs, all with gyttja, the panicle shoots had an average length between ca. 250 and 320 cm. See Fig. 133.

In the windy coastal biotopes the leaf tips were often broken and torn, and therefore the leaf length and area could only occasionally be determined (Table 51). As for the multileaved shoots in 42 Pukavik the leaf area was about 10 dm² per panicle shoot. It was ca. 5.5 in 40 Orrekulle and 41 Pukavik, ca. 3.6 in 48 Hakenäs, and <3 dm² in 46 Praestö Fjord, 44 Lödösnäs, and 47 Ängen.

The characteristic length of the stomatal guard-cells of the middle leaves was of the order of 21—24 μ m (Table 50). In the dense-growing stand in the plaur biotope 42 Pukavik a value greater than 25 μ m was found, but judging from a great material this was an exception. The stomata density on the middle leaves was always greater than 1000 per mm².

In all coastal biotopes the shoot density was high. It was of the order of about 75—100 in 41—42 Pukavik and 43—44 Lödösnäs, ca. 100—150 in 40

Orrekulle as well as in 48 Hakenäs and ca. 250 in 45 B Bjärred and 47 Ängen. The highest density of green shoots, viz., about 700, was found in 45 C Bjärred. In 46 Praestö Fjord the number of green shoots, at the time when these were full-grown, was about 180. However, if all shoots developed during the vegetation period were included, the shoot density should be ca. 400. Also in 45 B—C Bjärred the number of dry shoots was high.

The lowest panicle frequency, ca. 10 %, was found in the plaur biotope 42 Pukavik and the highest, 90 %, in 44 Lödösnäs. The series 60, 30, and 20 % was obtained from the shore in a seaward direction in the Bjärred 45 A—C biotopes. In the other biotopes the frequency varied from 40 to 80 %.

The earliest flowering occurred in the latter part of August in 47 Ängen, 48 Hakenäs, and 44 Lödösnäs. Most of the clones flowered in the middle of September, but in 45 C Bjärred the flowering did not take place until the end of the month.

The leaf area per m² was determined only from four biotopes (Table 51). It was about 190 dm² in 44 Lödösnäs, 330 in 46 Praestö Fjord, 460 in 40 Orrekulle, and 520 in 41 Pukavik.

The standing crop varied from about 900 g in 44 Lödösnäs to about 1500 g in 40 Orrekulle and 41 Pukavik (Table 53).

The analyses of expressed sap and press-cakes (Tables 54—55) are discussed in the Synthetic Part.



Fig. 133. Panicles and shoots from biotopes on the coasts of South Sweden and Zealand. The biotope 42 panicles from 1957, 1960 and 1961.

TABLE 47. Water analyses.

Biotope	Date	SW IWP, IWS	Samp- ling level cm	Water, Pit depth cm	θ °C	Col Pt mg/l	Sp.cond. µS	pH	Na	K	Mg	Ca	Fe	Cl	P	Alk µeq/l
												µmol/l				
40 Orrekulle	630910 640830	SW/IWP IWP	0 -5	10 25	13.7	80	4900 11200	6.6 6.3	40900 96700	885 2130	4600 11700	1000 3100	18	46500 115000	1.6 .	3890
	630817	SW	0	60	20.5	10	11200	8.7	94600	2520	11300	2400	.	111000	.	1450
41 Pukavik	630928	SW	0	40	10.8	10	9700	7.5	81700	2230	9500	2100	3	93500	3.8	1570
	633010	SW	0	65	6.6	40	3800	7.2	30400	770	3800	1100	3	34500	1.1	1120
	640830	SW	0	4	12.7	15	11700	7.0	101000	2550	11700	3700	2	118000	.	1690
	630530	SW	0	35	22.5	.	1000	8.3	6570	190	640	700	.	7800	.	.
42 Pukavik	630928	SW	0	30	11.6	15	10000	7.4	89600	2340	9800	2300	3	99200	3.1	1570
	640830	SW	0	6	14.3	25	12200	7.1	105000	2650	12300	3600	2	123000	.	1900
	630528	SW	0	25	22.0	.	10200	9.3	87500	2110	.	.	.	98400	.	.
	630621	SW	0	40	18.1	35	3900	7.9	26900	790	.	.	.	33000	.	3250
	630723 ^{*2}	SW	0	35	15.0	70	8800	6.9	71700	1670	8800	3700	9	83000	29	5280
Löddesnäs ^{*1}	630723 ^{*3}	SW	0	48	25.1	40	10400	8.9	87000	2080	10300	3300	3	100900	15	3220
	630726	SW	0	51	17.3	60	7100	7.4	57400	1590	6500	3000	5	65200	13	3140
	630819	SW	0	38	19.8	60	3800	7.5	29600	820	3600	2100	6	32600	5.4	3020
	630926	SW	0	59	12.1	60	3500	7.6	25200	910	1100	2400	4	29800	12	3310
	631029	SW	0	37	7.9	40	4400	7.5	34700	970	4200	2600	3	38700	5.3	4090
	630528	IWP	-22	55	10.7	.	9600	6.6	82300	1420	.	.	.	91100	.	.
	630621 ^{*2}	IWP	-5	35	13.5	65	10400	6.4	90000	1880	.	.	.	99500	.	3160
	630723 ^{*3}	IWP	-10	35	13.8	80	7700	6.7	63600	1480	6900	3700	15	71200	11	4220
	630723 ^{*3}	SW/IWP	0	3	19.7	60	8500	7.4	71300	1660	8600	3400	3	79200	26	4640
	630726	SW	0	6	16.0	60	7200	7.3	58300	1650	6400	3100	5	65900	14	3210
43 Löddesnäs	630819	IWP	-7	35	15.0	90	7900	6.6	66100	1800	7800	3000	13	74900	33	6050
	630926	SW	0	14	11.7	60	3800	7.4	27800	1030	3300	2400	7	33000	14	3080
	631029	IWP	-3	35	8.8	120	8300	6.7	72700	1640	8300	3400	5	79300	33	7430
			-13	.	.	.	10800	6.8	89300	2180	10600	4000	18	101100	9.0	9000
			-26	.	.	160	10000	7.2	84700	2170	10000	4000	38	93000	14	2580
	630726	IWS	-40	.	.	240	9900	7.5	83800	2130	9500	4300	60	91000	21	4100
			-53	.	.	160	11700	7.8	98500	2690	11200	4300	17	109700	15	8590
			-80	.	.	160	11900	8.1	102300	3080	10100	4000	13	113700	17	11700
44 Löddesnäs	630804	IWP	-7	40	15.8	90	3800	6.3	26600	580	4500	3500	35	29300	6.2	3320
	630926	SW	0	5	11.2	75	1500	7.2	9450	490	1300	1800	2	10100	9.2	2920
	631210	IWP	-2	35	1.4	80	1900	6.7	13500	350	1550	2000	32	14600	.	4550
45A Bjärred	630717	IWP	-7	53	15.7	30	10500	6.7	79500	2110	13100	9300	3	91800	1.0	5790
45B Bjärred	630613	SW	0	12	21.2	40	2800	9.0	12600	520	2500	2200	.	22300	.	3550
	630717	SW	0	25	22.5	40	8300	8.6	71300	1940	8400	3000	5	79900	13	3230
	631029	SW	0	20	7.5	30	2200	7.7	13200	490	1900	2000	2	14800	6.1	3740
	630613	IWP ^{*4}	-15	35	17.1	70	7300	7.3	23800	1280	5900	3600	.	67100	.	7300
45C Bjärred	630716	SW	0	20	25.2	30	2800	9.5	12800	520	2400	2400	.	23200	.	3600
	630716	SW	0	45	22.2	30	10400	9.0	85200	2230	9800	2800	3	105400	9.6	2640
	630717	SW	0	40	22.9	35	8100	8.8	65200	1870	7800	3000	4	78200	10	3080
	631029	SW	0	65	7.8	25	3400	7.7	25400	700	3100	2400	3	28500	4.8	3380
46 Praestø Fjord	630901	SW	0	.	16.0	15	12800	7.6	114800	2910	13200	2800	3	131500	2.0	1880
	640824	SW	0	28	15.1	5	15300	7.8	136300	3370	15800	3900	1	159100	.	1780
47 Ången	630820	SW	0	18	17.5	50	4300	8.8	34800	1050	4100	1100	5	39000	1.6	1120
48 Hakenäs	630821	SW	0	13	21.3	15	27800	8.2	260900	6470	31000	5100	.	304500	4.8	1840

*1 = sampling site situated ca. 3 m south of the sampling site in biotope 43. *2 = h 6.00. *3 = h 12.30. *4 = sampling in pit dug in the tussock. *5 = sampling outside the tussock.

TABLE 48. Polyploid level and pollen quality.

Biotope	Polyploid level	Pollen quality (F) (D)
40 Orrekulle	4x	.
41 Pukavik	4x	93
41A Pukavik	4x	.
42 Pukavik	4x	63
43 Löddesnäs	4x	87
44 Löddesnäs	4x	93
45A Bjärred	.	33
45B Bjärred	4x	.
46 Praestö Fjord	4x	80
47 Ängen	4x	90
48 Hakenäs	4x	.

TABLE 49. Biometric analyses of pollen.

Biotope	Date	n	m	e	µm	s	min	max	Pollen volume 100 µl	min	max
40 Orrekulle	631006	225	28.9	0.09	1.38	25.9	32.9	92	128	188	
41 Pukavik	600909	225	27.5	0.08	1.18	24.5	30.1	78	110	144	
41A Pukavik	600909	225	26.1	0.10	1.55	21.0	30.8	49	94	153	
42 Pukavik	550930 560910 570919 580912 600909	675 675 675 675 225	29.5 30.0 29.6 30.2 29.5	0.08 0.10 0.08 0.09 0.14	2.17 2.60 1.99 2.27 2.11	22.5 21.6 23.4 21.6 24.5	37.8 41.4 39.6 38.7 36.4	60 53 67 53 78	136 141 136 144 136	283 372 325 306 253	
43 Löddesnäs	630908	225	25.2	0.09	1.34	21.0	30.1	49	84	144	
44 Löddesnäs	630828	225	26.1	0.11	1.65	22.4	30.8	59	94	153	
45A Bjärred	660828	225	27.7	0.12	1.74	23.1	32.9	65	113	188	
45B Bjärred	621004	225	29.5	0.15	2.30	23.8	37.1	71	136	270	
46 Praestö Fjord	630901	225	26.5	0.12	1.78	23.1	33.6	65	99	199	
47 Ängen	630820	225	27.6	0.10	1.53	21.7	32.2	54	110	175	
48 Hakenäs	630821	225	27.7	0.10	1.53	23.8	32.9	71	113	188	

TABLE 50. Biometric analyses of stomata.

Biotope	Date	Shoot type	Shoot length cm	Leaf				Guard-cell length				Stomata		Leaf area			
				No.	Insertion level cm	Length cm	Breadth mm	Area cm ²	μm				density no./mm ²	x stomata density			
									n	m	e	s					
												n	m	x 1000			
40 Orrekulle	630910	PS	247	1	198	47	28	70	50	21.4	0.20	1.44	10	1320	92		
			4	228	43	21	44	50	20.9	0.21	1.46	10	1390	61			
			9	243	26	13	19	50	20.2	0.17	1.18	10	1330	25			
			5	251	47	26	67	50	21.1	0.24	1.72	10	1340	90			
41 Pukavik	610922	PS	316	5	264	-	31	-	50	22.5	0.24	1.69	10	1240	-		
			315	7	277	41	26	53	10	22.8	0.35	1.11	10	1200	64		
			330	3	259	-	37	-	10	22.8	0.35	1.11	10	1150	-		
			315	7	282	-	22	-	10	22.0	0.56	1.78	10	1180	-		
41A Pukavik	610922	PS	311	9	-	37	25	46	10	24.3	0.51	1.63	10	1060	49		
			343	7	-	40	28	59	10	24.7	0.38	1.19	10	1030	61		
			326	9	-	39	27	55	10	26.0	0.61	1.94	10	1100	62		
			1	182	46	38	83	50	25.5	0.25	1.80	10	950	79			
42 Pukavik	610922	PS	274	5	229	48	34	79	50	22.5	0.19	1.37	10	1340	106		
			10	257	37	22	41	50	22.5	0.20	1.38	10	1330	55			
			6	250	40	29	61	50	24.1	0.22	1.57	10	1200	73			
			298	7	253	45	35	81	50	25.9	0.23	1.64	10	1230	100		
	610922	PS	269	9	248	36	20	39	50	22.2	0.23	1.60	10	1400	55		
			1	403	33	13	53	50	23.6	0.22	1.38	10	950	77			
			660911	PS	260	6	220	40	27	57	50	22.4	0.20	1.45	10	1220	70
			11		242	30	17	26	50	22.1	0.18	1.30	10	1300	34		
660911	PS	243	6	210	38	24	46	50	21.4	0.17	1.18	10	1370	63			
		1	196	46	32	78	50	23.1	0.25	1.80	10	1160	90				
43 Löddesnäs	630908	PS	282	5	233	45	30	72	50	23.1	0.13	0.95	10	1270	91		
			9	256	36	18	38	50	22.2	0.19	1.37	10	1360	52			
			5	234	47	30	79	50	23.9	0.28	1.98	10	1150	91			
			2	174	42	31	70	50	24.1	0.09	0.65	10	1080	76			
44 Löddesnäs	630828	PS	235	4	193	42	26	55	50	23.4	0.23	1.65	10	1170	64		
			6	208	33	18	32	50	22.5	0.18	1.24	10	1290	41			
			5	198	45	30	72	50	23.2	0.21	1.46	10	1210	87			
			1	124	40	26	55	50	24.0	0.23	1.62	10	1070	59			
45A Bjärred	660829	PS	220	5	171	36	23	44	50	22.8	0.23	1.62	10	1310	58		
			8	189	32	16	24	50	23.1	0.19	1.33	10	1420	34			
			4	162	38	23	45	50	23.7	0.24	1.69	10	1200	54			
			1	174	47	30	79	50	22.6	0.21	1.49	10	1450	115			
45B Bjärred	660829	PS	245	4	193	43	25	53	50	21.8	0.18	1.28	10	1610	85		
			6	205	40	21	51	50	22.1	0.20	1.43	10	1580	81			
			4	178	47	28	70	50	21.6	0.19	1.34	10	1530	107			
			1	145	43	23	54	50	21.8	0.21	1.46	10	1300	70			
45C Bjärred	660829	PS	204	5	168	40	21	51	50	21.9	0.23	1.61	10	1490	76		
			8	183	30	14	24	50	22.5	0.16	1.13	10	1390	53			
			5	173	45	25	53	50	21.2	0.21	1.51	10	1500	80			
			3	154	35	24	45	50	21.7	0.29	2.07	10	1370	62			
46 Praestö Fjord	630901	PS	216	6	181	29	18	31	50	22.1	0.16	1.16	10	1380	43		
			8	193	24	14	21	50	21.6	0.20	1.41	10	1440	30			
			2	139	38	23	45	50	22.9	0.22	1.58	10	1110	50			
			4	154	35	19	36	50	22.8	0.21	1.51	10	1150	41			
47 Ängen	630820	PS	199	6	167	27	16	24	50	22.2	0.23	1.64	10	1080	26		
			2	138	38	30	66	50	26.1	0.22	1.58	10	1010	67			
			6	181	38	25	49	50	24.1	0.18	1.32	10	1280	63			
			10	208	26	14	20	50	22.5	0.21	1.45	10	1330	27			
48 Hakenäs	630821	PS	220	6	167	37	23	45	50	23.6	0.18	1.25	10	1250	56		
			6	167	37	23	45	50	23.6	0.18	1.25	10	1250	56			

TABLE 55. Environmental conditions at samplings, description of samples for sap expression and analyses of whole samples, press-cakes and expressed sap. All biotopes in light.																																										
Shoot part	Biotope	Shoot type	Sample no.	Date	h	Wind velocity	Cloudiness	Air temp. °C	Rh %	Water depth cm	Object dimensions				Insertion levels, cm				Whole sample			ES ml/kg FW	Press cake			W 3 % of whole sap	DM 3			A 3 % of DM 3	Colour (Pacit 1958)	ΔT °C	O ₂₀ atm	Sp.cond. mS	pH	Na	K	Mg	Ca mmol/l	Fe	Cl	P
											Length, cm		Breadth, mm		Thick-ness mm	Lowest	Highest	Mean	Range	W 1 % of FW	DM 1 % of FW		A 1 % of DM 1		W 2 % of DM 1		DM 2 % of DM 1	A 2 % of DM 2														
											Lower leaf	Upper leaf	Lower leaf	Upper leaf									A 1	A 2																		
Rhizomes	41 Pukavik	-	20/63	630530	14.30	2	Cloudless	22.6	46	35	.	.	.	.	16	25	5	.	82.6	174	10.3	524	34.0	84.6	42.3	2.97	95.4	15.4	57.7	22.3	Flav 0-1	0.876	11.4	15.7	5.3	76	118	1.4	6.8	.	117	9.0
		-	30/63	630617	12.30	2	Partly cloudy	20.6	60	40	.	.	.	.	16	30	5	.	83.6	164	11.7	600	29.1	90.6	34.7	2.74	97.5	9.4	65.3	49.5	Chlor 0-1	0.733	9.5	16.5	5.3	75	108	4.8	2.4	0.08	122	.
		PS	146/63	630817	14.00	2	Cloudless	18.8	60	60	.	.	.	.	16	30	5	.	76.1	239	14.3	501	36.4	88.4	43.9	2.98	94.6	11.6	56.1	29.1	Flav 0-1	1.031	13.4	22.1	5.4	109	154	7.4	2.9	0.10	159	.
		PS	201/63	630928	11.30	3	Cloudless	13.3	56	40	.	.	.	.	16	30	5	.	76.3	237	17.1	542	31.0	85.2	34.2	2.90	93.7	14.8	65.8	32.1	Flav 0-1	1.235	16.3	22.9	5.7	101	185	7.8	2.6	0.06	167	.
		PS	221/63	631030	14.00	2	Overcast	.	.	65	.	.	.	.	16	25	5	.	73.8	262	17.8	475	38.1	86.9	43.7	3.41	93.0	13.1	56.3	29.2	Flav-chlor 0-1	1.257	16.3	22.9	5.7	101	185	7.8	2.6	0.06	167	20.5
		-	9/63	630528	15.00	3	Cloudless	22.6	37	0	.	.	.	.	16	25	5	.	79.9	201	14.1	438	44.1	85.4	55.4	4.54	93.8	14.6	44.6	21.4	Flav 0-1	1.046	13.6	15.7	5.1	102	96	3.9	10.3	.	103	.
		PS	89/63	630723	10.00	2	Cloudless	20.4	73	0	.	.	.	.	16	25	5	.	80.6	194	13.6	566	31.4	86.1	40.7	3.31	95.2	13.9	50.0	39.8	Flav-chlor 0-1	0.763	9.8	16.1	5.3	103	86	5.0	4.5	0.12	113	.
		PS	93/63	630723	15.30	3	Partly cloudy	22.4	56	5	.	.	.	.	16	25	5	.	76.4	235	13.5	490	37.2	91.7	52.4	3.28	94.8	10.1	50.0	39.8	Flav 0-1	0.947	12.3	17.1	5.5	93	107	4.8	3.8	0.07	127	.
		PS	96/63	630723	19.00	2	Partly cloudy	21.1	56	0	.	.	.	.	16	25	5	.	79.1	209	13.4	556	31.1	88.1	42.9	3.12	95.6	11.9	57.1	30.8	Flav 0-1	0.828	10.7	17.2	5.3	78	119	3.3	4.3	.	128	.
		PS	120/63	630819	18.00	3	Cloudless	15.6	72	0	.	.	.	.	16	25	5	.	76.8	232	15.4	491	37.7	88.4	48.8	3.68	94.7	11.6	51.2	29.3	Flav-chlor 0-1	1.019	13.2	18.3	5.4	89	135	6.4	3.6	0.09	136	.
43 Lödösnäs	PS	184/63	630926	13.30	6-7	Overcast	11.9	82	14	.	.	.	.	16	25	5	.	73.3	267	15.4	419	45.1	87.7	58.4	3.85	92.5	12.3	41.6	19.6	Flav-chlor 0-1	1.225	15.9	16.2	5.6	83	136	7.4	4.5	0.11	115	.	
	PS	211/63	631029	11.00	2	Overcast	.	.	0	.	.	.	.	16	25	5	.	76.0	240	17.4	558	30.1	79.2	50.0	4.58	91.4	20.8	50.0	17.5	Flav-chlor 0-1	1.295	16.8	16.4	5.8	74	145	5.7	2.6	0.04	125	.	
	-	36/63	630622	14.30	2	Partly cloudy	18.1	74	0	.	.	.	.	13	25	5	.	76.3	237	12.3	471	39.5	92.5	57.4	3.21	96.3	7.5	42.6	29.5	Chlor 0-1	0.696	9.0	14.0	5.1	49	105	5.7	4.8	0.12	83	.	
	PS	111/63	630804	15.30	3	Cloudless	19.2	54	0	.	.	.	.	13	25	5	.	72.0	280	12.1	434	41.8	90.7	54.8	2.61	94.1	9.3	45.2	21.1	Flav-chlor 0-1	0.864	11.1	14.7	5.3	40	128	4.3	6.7	.	97	.	
	-	7/63	630522	16.00	3	Cloudless	19.2	54	0	.	.	.	.	13	25	5	.	76.6	234	14.5	416	44.9	86.5	57.7	4.13	93.0	13.5	42.3	19.4	Flav 0-1	1.143	14.8	15.2	5.2	81	116	5.3	10.0	.	118	19.5	
	PS	74/63	630717	17.00	2	Cloudless	20.2	54	0	.	.	.	.	13	25	5	.	88.1	119	12.0	738	17.4	79.3	23.0	2.91	96.7	20.7	77.0	37.4	Chlor 1	1.042	13.5	17.6	5.0	133	91	7.5	10.7	.	119	25.5	
	-	5/63	630522	15.30	3	Cloudless	18.8	83	5	.	.	.	.	13	25	5	.	77.2	228	16.1	421	44.1	89.7	57.7	4.13	93.0	13.5	42.3	19.4	Chlor 1	0.966	12.5	17.5	5.3	132	87	8.3	5.9	0.06	127	.	
	PS	216/63	631029	15.00	2	Overcast	8.0	77	20	.	.	.	.	13	25	5	.	77.9	221	15.0	455	42.7	90.2	53.4	4.03	95.4	13.2	50.0	22.9	Flav-chlor 0-1	1.310	17.0	18.8	5.6	109	139	7.4	3.1	0.05	130	.	
	-	69/63	630707	15.00	2	Overcast	15.9	80	18	.	.	.	.	13	25	5	.	73.7	263	15.9	453	40.9	86.8	50.0	3.49	92.6	13.2	50.0	22.9	Chlor 0-1	1.067	13.8	18.3	5.5	92	119	6.4	6.2	.	155	.	
	PS	127/63	630820	19.00	1	Overcast	15.9	80	18	.	.	.	.	13	25	5	.	69.2	308	12.9	383	46.3	92.1	59.3	3.49	92.6	13.2	50.0	22.9	Flav 0-1	1.683	21.9	20.5	5.5	161	124	9.5	5.2	0.09	212	.	
PS	131/63	630821	14.00	1	Partly cloudy	17.2	59	15	.	.	.	.	10	25	5	.	69.5	305	18.3	449	39.4	83.1	53.1	3.84	89.1	16.9	46.9	16.7	Chlor 1	1.151	14.9	18.3	5.9	27	200	11.6	4.3	0.04	94	.		
Next year's shoots	43 Lödösnäs	-	212/63	631029	11.00	2	Overcast	.	.	0	.	.	.	.	8-18	.	.	.	76.5	235	16.3	477	40.1	85.2	49.2	3.98	93.0	14.8	50.8	23.8	Chlor 1	1.223	15.9	20.4	5.7	41	203	8.1	4.8	0.05	117	.
	45C Bjärred	-	215/63	631029	15.00	2	Overcast	.	.	20	.	.	.	.	5-25	.	.	.	76.5	235	16.2	478	40.0	85.4	46.3	3.73	93.0	14.6	53.7	25.3	Chlor 1	1.223	15.9	20.4	5.7	41	203	8.1	4.8	0.05	117	.
Shoots of the year	45A Bjärred	-	6/63	630522	16.00	3	Cloudless	19.2	54	0	25	.	.	.	.	.	.	.	86.8	132	12.4	691	17.8	80.1	23.9	2.82	96.4	19.9	76.1	36.0	Flav 4	0.718	9.3	15.2	5.3	10	160	3.7	8.2	.	61	13.2
	-	27/63A	630613	16.30	3	Cloudless	19.0	74	0	30	.	.	.	.	.	.	.	.	86.7	133	12.9	693	20.0	79.3	24.5	3.01	96.2	20.7	75.5	35.5	Flav-chlor 2	1.041	13.5	20.3	5.3	62	164	6.2	11.9	0.08	134	.
Lower leaves	41 Pukavik	-	2/63	630522	15.00	3	Cloudless	20.2	52-54	0	15-25	.	.	.	.	.	.	.	86.7	133	12.9	693	20.0	79.3	24.5	3.01	96.2	20.7	75.5	35.5	Flav 4	0.798	10.3	14.8	5.6	19	154	4.3	6.4	.	70	13.6
		-	3/63	630522	15.00	3	Cloudless	20.2	52-54	0	30	.	.	.	.	.	.	.	86.7	133	12.9	693	20.0	79.3	24.5	3.01	96.2	20.7	75.5	35.5	Flav 4	0.886	11.5	17.6	5.6	22	175	6.1	10.0	.	110	12.4
		-	4/63	630522	15.00	3	Cloudless	20.2	52-54	0	30	.	.	.	.	.	.	.	86.7	133	12.9	69																				

SYNTHETIC PART

Ecology of *Phragmites communis*

In this part facts on the organism *Phragmites communis* and its environment presented in the Analytic-Descriptive Part are synthesized. The syntheses

in the first section are made with the variation and variability in the species as a starting point.

I. Variation and Variability in *Phragmites communis*

The variation and variability in *Phragmites communis* with respect to different shoot qualities are illustrated by the comprehensive material of statistical descriptions in Tables 10, 11, 20, 31, 40, 43 and 51. In a regio-limnologic study on a plant species like *Phragmites communis* it is difficult to obtain a material which from a biological point of view is of such a homogeneity that it is permissible to make comparisons by means of statistical analyses. This is the case with respect to material from different sampling occasions in the same biotope as well as to material from different biotopes. Therefore, in this paper the biometric conditions of the shoots as well as of pollen and stomata have been

statistically described only and not statistically analysed. By means of descriptions of material from different years from one and the same biotope a conception of the average values is obtained. Furthermore, the biotopes are selected so that the differences in the shoot qualities which were intended to be shown are clearly demonstrated already in the statistical descriptions. Therefore simple sampling methods could be employed, thus making it possible to carry out this synoptic investigation.

In the selection of the biotopes an attempt has been made to illustrate the variation between different clones as well as the ability of modification within the clones.

Polyploid Levels

Reviews of chromosome determinations in *Phragmites communis* are given by LÖVE & LÖVE (1961), BJÖRK (1963) and GUSTAFSSON & SIMAK (1963). The hitherto known chromosome numbers in the species are multiples of 12. This is given as the basic number by AVDULOW (1931) and TARNAVSCHI (1948), while the number 6 is stated by LÖVE & LÖVE (op.c.). In the designation of the polyploid levels in this paper, 12 is used as the basic number.

At Willmersdorf near Luckau in Germany there is a long well-known stand of a tall *Phragmites* type, "*Phragmites communis* var. *pseudodonax*" (KRAUSCH 1956). This as well as a common type of *Phragmites* from a lake in Northeast Poland has been declared to be triploid (TISCHLER 1918, 1942). In India a triploid type is said to be found too (RAMANATHAN 1950).

Phragmites communis at the tetraploid level is reported from several different regions of the world, viz., from Delta del Paraná and Mendoza in Argentina (SAURA 1948), North America (LÖVE 1954), England (HUNTER 1934), Kiev, Kossino and Detskoje Selo in the USSR (AVDULOW 1931), Denmark (HAGERUP 1941), from several localities throughout Sweden (BJÖRK 1963) as well as from different localities in the marshes around the junction of the Tigris and Euphrates in Iraq (BJÖRK 1966).

The finding of clones at the hexaploid level in Ysane parish in Blekinge, South Sweden, has been published by BJÖRK (1963). The Ysane clones are the same as those in biotopes 26—27 Norjesund in this paper.

A heptaploid type was found in Rou-

mania (TARNAVSCHI 1948) and an octoploid reported from Suchum on the Black Sea (AVDULOW 1931) as well as from A. Sefra, southern slope of Sahara Atlas in Algeria (REESE 1957).

According to GUSTAFSSON & SIMAK (1963, p. 443) "some results, including those of TISCHLER, seem to need a careful rechecking". Compare also TISCHLER 1929 and AVDULOW 1931.

In limnologic investigations comparisons are often made between biotopes concerning the production of organic matter by different organisms. In these investigations the environmental conditions are often very well described, but the definition of the organisms must be mostly restricted to names, in many cases designations for species complexes. For elucidation of problems with respect to the variability within the organism material (including the production variability within a species complex), more frequent collaboration between limnologists and, for example, geneticists and plant physiologists would be highly desirable (compare LEXANDER 1963 and STOY 1965).

As for the limnic macrophytes polyploids are frequent (cf. TISCHLER & WULFF 1963, p. 637 ff. and the papers referred to there). Variations in the chromosome number (see, e.g., LOHAMMAR 1931, BJÖRKQVIST 1961 and STRANDHEDE 1966) and clone formation in connection with vegetative propagation (cf. GUSTAFSSON 1948) make it often difficult to carry out true evaluations of the productivity in different environments.

From a genetic point of view the common reed is characterized by GUSTAFSSON & SIMAK (1963, p. 447) as follows: "There is every reason to believe that *Phragmites communis* is a highly heterozygous and polymorphous species, occurring in a great number of clonal genotypes . . . Possibly the species contains various chromosome numbers, too".

*

The chromosomes in *Phragmites* are small and, in spite of pretreatment by cooling of the roots, the number was in some cases — especially with respect to the hexaploids — difficult to determine. In this investigation the aim was to determine the polyploid level. As far as I know, no types with extra chromosomes are included. The presence of extra chromosomes in clones at the tetraploid level in other biotopes than those treated here has been reported from Sweden (BJÖRK 1963).

Phragmites from all biotopes treated in this paper are either at the tetraploid or at the hexaploid level (see Tables 7, 17, 28, 37 and 48). As pointed out in a previous paper (BJÖRK op.c.), the tetraploid type seems to be the most common one in Sweden and probably it is also the most common one all over the world.

Hexaploid clones are described here only from biotopes 26, 26 A, 27 and 27 A—C Norjesund and from 30 Jägern. In Norjesund two different types at the hexaploid level occurred. Their distribution in 1962 is shown in Fig. 85. One of these hexaploid types, "type A", growing in biotopes 26 and 26 A, is tall and characterized above all by a much later flowering than "type B", growing in biotopes 27 and 27 A—C (cf. Fig. 138). The stability of the morphologic characteristics of the shoot qualities was in both types checked in cultivation experiments (cf. p. 202). The differences between the two types at the hexaploid level in Norjesund must be caused by differences in the genetic constitution.

In several characters in the shoot morphology (including the well-developed panicle) the hexaploid type in biotope 30 Jägern resembled "type B" in Norjesund.

Phragmites at the tetraploid level was found in all other biotopes. As has been shown in the Analytic-Descriptive Part, there is in *Phragmites* at this level an enormous variability, for example, in the dimensions of different shoot qualities. For studying the ability of modification in different clones, large-scale cultivation experiments are, of course, necessary. The results of some reconnoitering experiments carried out by the present author will be published later.

As experiments of this kind with *Phragmites* are very time-consuming, an attempt has been made in this paper to illustrate the variation within the tetraploid level by selecting sampling areas with homogeneous environmental conditions where old and well-established stands of highly different clones are represented. Biotopes between which comparisons of this kind are possible are above all 33—34 W. Ringsjön, 38—39 Tystrup Sö, but also 28—29 Norjesund. Also, though not subjected to closer investigation, the biotopes 41—41 A Pukavik are useful in this connection.

On the other hand, the ability of modification in *Phragmites* could be studied directly in nature in clones spread over an area within which the environmental conditions are heterogeneous. Comparisons of this kind could be made concerning the biotopes 5—6 Helgasjön, 7 A—D Furen, 19—20 Vångasjön and 22—23 Orlunden. Probably such comparisons could also be carried out between biotopes in the same lake as, for example, 1—2 Fiolen, 3—4 Stråken and 10—11 Rolsmosjön. However, in these cases there are no connections in which the successive transition from one modification to the other could be studied. Very good possibilities for stu-

dying the ability of modification in *Phragmites* are found in connection with local auxotrophifications, especially in oligotrophic regions. This is exemplified here by the biotopes 7 A—D Furen.

No descriptions are available of the environmental conditions in the biotopes outside Sweden in which the hepta- and octoploid types have been found. It is shown in this paper that tetraploid *Phragmites* grows in biotopes which differ greatly in environmental conditions. Hexaploid *Phragmites*, on the other hand, is known from Norjesund

and Lake Jägern only. Of course the observation material is too limited to allow conclusions about the ecologic valency of *Phragmites* at this level. However, in the biotopes where clones at this level have been found there is a rich supply of nutrients. It has also been shown, that a transplantation of plant material from the Norjesund clones to a poor environment is accompanied not only by a dimensional decrease, but the panicle formation is inhibited (cf. the cultivation experiments described on p. 202).

Pollen Quality

From the estimations of the percentage of morphologically good pollen it is obvious that there is a marked difference between the hexaploid Norjesund clones and other analysed clones (see Tables 7, 17, 28, 37 and 48). The highest value for all hitherto available samples from the hexaploid type A in Norjesund is 5 % good pollen and no sample in type B had more than 10 % good pollen (Table 28). The frequency of abnormal, often granulated pollen grains was high.

The hexaploid clone in biotope 30 Jägern differed from those in Norjesund as 80 % of the pollen was estimated as morphologically good.

In most cases the tetraploid types proved to have high or fairly high frequencies of good pollen. Values from

37 clones in different biotopes are available. From these the estimated percentage of morphologically good pollen was higher than 90 in 4, 80—90 in 21 and lower than 80 in 12. In the last-mentioned group 6 had 70 % and upwards, 4 had 60—65, 1 had 50 and 1 had 33 % good pollen.

Comparatively low frequencies were found in parts of the Veden-Tiken-Ängsjön region and also in the northern part of the Orlunden-Norjesund region, but the lowest occurred in Norjesund and Bjärred. Thus low as well as high frequencies occurred in three out of the five biotope regions. From the Aneboda and the eutrophic regions no clone with lower frequency than 80 % is included.

Pollen Size

The distribution of pollen of different sizes in different parts of inflorescences and flowers as well as in flowers of various generations in the same plant are described by several authors.

According to OVTSCHINNIKOV (1951) the largest pollen grains in *Avena* occur in the top of the panicle and in *Helianthus* in the periphery of the capitulum. Also in *Secale* differences in pollen size are said to be

found between different parts of the ear according to OVTSCHINNIKOV & SCHICHANOVA (1953).

SCHWANITZ (1952) pointed out that in plant species with long flowering period, exemplified by *Malva*, *Verbascum* and *Tro-paeolum* spp., the pollen grain size diminishes during the flowering period.

Here the pollen size differences in the species with heterostyly should also be recalled. The smallest pollen is found in the lower, the largest in the highest situated anthers. Judging from investigations on *Lythrum salicaria*, characterized by trimorphic heterostyly, SCHOCH-BODMER (1938) draws the conclusion "dass trophische Einflüsse bei der Entwicklung der Pollengrösse von *Lythrum salicaria* eine wesentliche Rolle spielen" and "dass sich die Pollengrösse durch einen Wechsel der Ernährungsbedingungen, dem die ganze Pflanze unterworfen wird, verändern kann, oder dass Blüten, die verschiedene Stellungsverhältnisse auf einem Individuum aufweisen, sich auch in ihrer Pollengrösse unterscheiden" (op. c., pp. 70, 72). Thus, the supply of nutrients within the plant as well as the trophic conditions under which the plant grows are considered to be essential for the pollen size.



Fig. 134. Panicle 4 in Table 56. Size determinations made on pollen from branches and branch groups 1—6.

In a critical examination of the pollen size distribution in *Primula* (with dimorphic heterostyly) ERNST (1953) found that "bei den 'normalen' Kurzgriffeln wird in hochstehenden Antheren grosser, in den tiefstehenden Antheren der 'normalen' Langgriffel kleiner Pollen ausgebildet. Die beiden Pollen-typen können darüber hinaus frei mit den

Table 56. The size distribution of pollen within the *Phragmites* panicle. Material from Lake Stråken. n=225.

Panicle no.	Panicle length cm	Part of panicle	Sampling date	Pollen diameter, μ m					Pollen volume μ l $\times$ 100 m
				m	e	s	min	max	
1	20	Top branch	560817	29.5	0.10	1.56	24.3	34.2	136
		Big base branch	560820	28.5	0.10	1.50	25.2	34.2	123
2	20	Top branch	560817	29.6	0.16	2.37	25.2	48.6	136
		Big base branch	560820	27.8	0.09	1.38	22.5	33.3	113
3	21	Top branch	560906	29.1	0.15	2.18	22.5	36.0	130
		Big middle branch	560906	29.1	0.17	2.53	21.6	40.5	130
		Small middle branch	560906	28.9	0.16	2.35	22.5	34.2	128
		Base branch	560906	28.6	0.13	1.92	22.5	33.3	123
		The whole panicle except the above parts	560906	28.9	0.16	2.33	21.6	36.0	128
		Top branch (1)	560906	29.1	0.14	2.12	24.3	36.0	130
		Big middle branch (2)	560906	29.0	0.12	1.83	24.3	34.2	128
4*	23	Big middle branch (3)	560906	28.4	0.14	2.07	21.6	35.1	120
		Six small middle branches (4)	560906	28.1	0.16	2.35	22.5	35.1	117
		Big base branch (5)	560906	28.5	0.16	2.45	20.7	38.7	123
		Two small base branches (6)	560906	28.0	0.17	2.62	18.9	39.6	115
		The whole panicle except the above parts	560906	28.5	0.14	2.07	21.6	36.9	123

* See Fig. 134

Unterschieden in der Antherenstellung kombiniert auftreten: kleiner und grosser Pollen kann in hoch- wie in tiefstehenden Antheren zur Ausbildung gelangen" (op. c., pp. 123—124).

Several investigations on the pollen size conditions in different parts of trees have been carried out. On the basis of comprehensive pollen size measurements in *Picea* and *Pinus* ANDERSSON (1954) concludes that the pollen size is influenced by both environmental and hereditary factors. Among other things it was shown that there is a positive correlation between exposure to light of the flowers and pollen size in *Picea*. With respect to *Pinus* there was a tendency to a negative correlation between exposure to light and pollen size. See also LANGLET (1939).

In the *Phragmites* panicles the largest pollen grains were found in top branches. The distribution by size of the pollen grains within panicles from Lake Stråken is illustrated in Table 56, accompanied by Fig. 134.

Broadly speaking, there is also a correlation between pollen size and flowering time in *Phragmites*. The earliest flowering panicle branches have the largest, the latest flowering the smallest grains. The flowering starts in the top branch, continues with the outer parts of the bigger upper side branches, and generally the flowering then proceeds from the top downwards. In warm and dry weather the time from incipient to full flowering of ca. 25 cm long panicles of shoots growing in shallow water in Lake Stråken was about 2 days. However, the time is very variable from clone to clone and from biotope to biotope.

In thorough pollen size comparisons between different clones it is important that the pollen samples have comparable origin within the panicles. With the exception of the data in Table 56 all pollen

sizes given in this paper were determined in samples obtained according to the method described on p. 20, i.e., an attempt was made to obtain a mixture of pollen from all parts of panicles in as new and complete flowering as possible. However, due to the regio-limnologic character of the investigation it was not always possible to realize this intention. In some cases the panicles were in an early, in other cases in a late stage of flowering. When comparing the differences in pollen size between the clones and biotopes the size distribution within the panicle should be kept in mind.

As for the correlation between polyploid level and pollen size in different plant species the reader is referred to, e.g., MÜNTZING (1927), SCHWANITZ (1950) and MAURIZIO (1956). In his investigation of *Cardamine*, LÖVKVIST (1956) found that "the mean value of the pollen diameter of a sample is often enough to place the plants at the correct chromosome level" (op. c., p. 31).

From a dimensional point of view the available data on *Phragmites* pollen in this investigation could easily be divided into two groups, viz., one with large and one with small grains. The large pollen grains are produced by the hexaploids, the small by the tetraploids (Fig. 135).

LÖVKVIST (op.c.) has also pointed out that different pollen sizes were found in *Cardamine* individuals with the same chromosome number but growing in different environments. Thus in collections from two biotopes the smallest pollen was found in the driest biotope.

In connection with investigations on *Galeopsis*, MÜNTZING (1927, p. 253) found that "it is evident that the pollen grain size is influenced by several developmental factors of which the chromosome number may be one". It is also pointed out that "in individual cases it is hardly possible to conclude from vegetative vigour to the size of the pollen grains" but

"an ill nourished plant most probably will show smaller pollen grains . . . than well nourished and healthy plants" (op. c., p. 246).

The pollen size of 40 grass species was investigated by JONES & NEWELL (1948), who conclude that "the difficulty of identifying many kinds of grass pollen on the basis of size alone is apparent. Variation in pollen size between strains within a species as well as the variation under different environmental conditions make such a task even more difficult" (op. c., p. 139).

MIKKELSEN (1948, 1949) stresses the importance of the trophic factor for the pollen dimensions. This author also considered that "insufficiently nourished plants had smaller pollen than well nourished plants" (1949, p. 324). MIKKELSEN (loc. cit.) also carried out investigations concerning the influence on pollen size of temperature, but "nutrition has such an important bearing on the size of the pollen that it is impossible to draw any conclusions about the influence of temperature on pollen size". Also SCHOCH-BODMER (1940) and WAGENITZ (1955) have pointed out the importance of the environmental conditions on the pollen size.

From STARK (1927) onwards the possibilities of identifying fossil pollen grains by means of size determinations have been very frequently used or attempted in pollen analysis. The reader is referred to investigations by, e.g., FIRBAS (1937), FAEGRI (1940), CAIN & CAIN (1944, 1948), GEISLER (1945), CHRISTENSEN (1946), WENNER (1948), ENEROTH (1951, with summary by TAMM of earlier size measurement studies for pollen diagnosis) and LEOPOLD (1956). ERDTMAN & NORDBORG (1961) pointed out the possibilities of distinguishing polyploid types of *Sanguisorba officinalis* by means of pollen size measurements. BERGLUND (1963 b, 1966) made use of this possibility in pollen analysis.

The results of the *Phragmites* pollen size measurements in this investigation are not comparable with earlier data as these have been obtained with several different and insufficiently known methods.

Within the tetraploid and hexaploid levels which with respect to the pollen

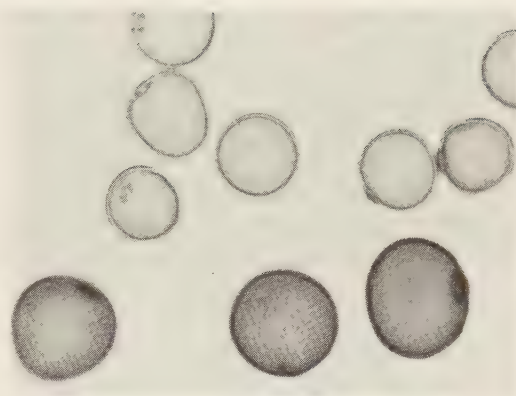
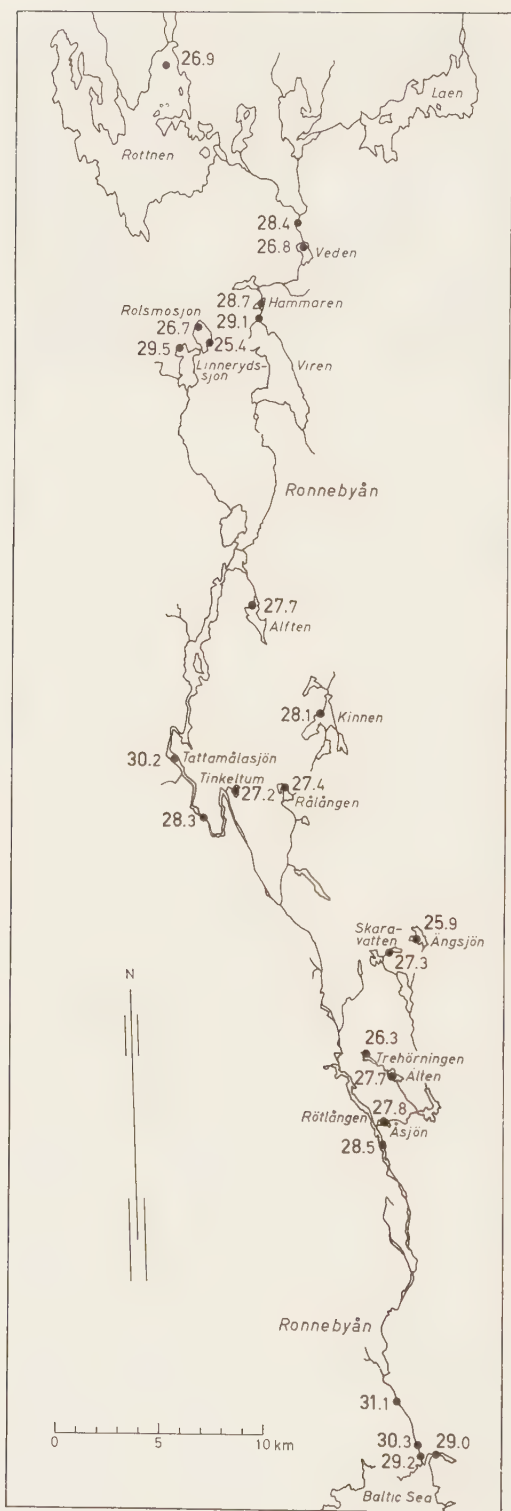


Fig. 135. Pollen of *Phragmites* from clones with in the Orlunden—Norjesund region 570923. Top: Pollen from the tetraploid clone in biotope 18 Vitavatten. Bottom: Pollen from the hexaploid clone in biotope 27 B Norjesund. Both pollen samples acetolysed. The pollen from Norjesund weakly stained with gentian violet.

dimensions are distinctly separated in the material from the biotopes in this study, a considerable size variation was found (see Tables 8, 18, 29, 38 and 49). In the tetraploids the range was from 25.2 (43 Löddesnäs) to 30.4 μm (8 Salen, basal parts of panicles not flowering) and in the hexaploids from 31.6 (30 Jägern) to 34.6 μm (26 Norjesund).

In some of those clones within the Orlunden-Norjesund region and also in biotope 42 Pukavik which have been analysed for several years with respect to pollen size, this characteristic proved to be comparatively stable in, for example, 18 Vitavatten and 22 Orlunden. This is probably due in part to the fact that the pollen samples had been collected here in all years from panicles in approximately the same stage of flowering. Also in 42 Pukavik the similarity in pollen dimensions was great between the different years. In this case, however, the samplings were made at different phases of the flowering. More-



over, the environmental conditions in this biotope were unstable (cf. p. 168 ff.).

On the whole, the different more thoroughly analysed clones in the Orlunden-Norjesund region and in 42 Pukavik proved to have characteristic and fairly stable pollen dimensions throughout the investigation period. The pollen samples were not always collected in all biotopes at the same phase of flowering and undoubtedly this is the main cause of the differences from year to year. With respect to environmental conditions before the flowering as, for example, temperature, precipitation and water level, there were rather great differences from one year to another, but these seem to have had a rather insignificant influence on the size variation.

It is impossible on the basis of available data to find any true correlation between pollen size and environmental conditions, particularly the trophic factor, in *Phragmites* at the tetraploid level. Thus the luxuriant stand of the clone, characterized by large panicles, in the auxotrophicated biotopes 9 A—B Trummen had smaller pollen than the clones in biotope 1 Fiolen and 18 Vitavatten, both with small shoots and panicles. Nor is it possible to demonstrate any general differences in pollen size between the clones in coastal and in fresh-water biotopes.

In *Phragmites communis* the variation in the pollen size seems to have mainly genetical causes. It was possible in, for example, the clone in biotopes 7 A—D Furen to study the ability of

Fig. 136. Sampling sites for *Phragmites* pollen within the watercourse system of the river Ronnebyån. The figures give the mean pollen diameter ($n=225$).

modification, as this clone is represented by a stand from which — due to local auxotrophication — different parts are growing under different environmental conditions (cf. p. 51 ff.). With respect to shoot dimensions and standing crop there was a strong reaction to the auxotrophication, but no comparable changes in the pollen dimensions were found. See Table 8. Compare also the biotopes 19—20 Vångasjön (p. 100 ff., Table 29).

As a supplement to the material presented in the Analytic-Descriptive Part measurements of random pollen samples from the river system of Ronnebyån are given in Fig. 136. It is seen that the smaller pollen was found in the lake biotopes in the oligotrophic regions around Ronnebyån and the larger in the

river biotopes which are in part heavily auxotrophicated (cf. p. 67). Especially in the lowermost polluted part of Ronnebyån the pollen grains were large in clones growing in biotopes with fine-grained minerogenic and clay gyttja sediments. Thus, in this case one gets an impression of a correlation between pollen size and environmental conditions. However, the polyploid level was determined only for clones in lakes within the Veden-Tiken-Ångsjön region treated above. These clones were all tetraploid. In any case, the measurements from Ronnebyån demonstrate the occurrence of clones with pollen grains of intermediate size in relation to the size groups reported above for the tetraploids and hexaploids.

Stomata

Also with respect to the stomatal dimensions there is a marked difference between the hexaploid and the tetraploid *Phragmites* clones. As an increase in the chromosome number is correlated mostly with an increase in the cell dimensions, the hexaploids have larger pollen grains and stomatal guard-cells than the tetraploids. On the other hand, the greatest stomatal density (number/mm²) is found in the tetraploids. The approximate limit between the two polyploid levels is in this material 25 µm for the guard-cell length and 1000 stomata/mm² (refers to the intercostal zones) for the density in the investigated area of the middle leaves (see p. 13).

The general rule in *Phragmites* is that the length of the stomatal guard-cells decreases and the density of the stomata increases in corresponding leaf areas

with increasing insertion level of the leaves (Tables 9, 19, 30, 39 and 50). The exceptions from this rule may in part be ecologically explained as the stomata with respect to frequency and guard-cell length are dependent on the environmental conditions at the development. As for corresponding conditions in other plant species compare, e.g., WALTER (1951, with several references), SCHWANITZ (1952), STÅLFELT (1960, including the references) and BIEBL (1958).

In *Phragmites* the ability of modification in the mentioned stomatal qualities seems to be small. Thus about the same values were found as for the middle leaves in, for example, the sheltered freshwater biotopes 4 Stråken and 12 Linnerydssjön as in the exposed coastal biotopes 43 Lödösnäs and 48 Hakenäs. The clone in the last-mentioned biotope

had the largest guard-cells among these four biotopes. In the Aneboda and Veden-Tiken-Ängsjön regions the shortest guard-cells were found in biotopes with poorly developed stands as in 1 Fiolen, 3 Stråken and 16 Ängsjön, but those of about the same length were also found in 33 W. Ringsjön and 36 Krankesjön.

The *Phragmites* stands in all biotopes treated in this study had an unlimited supply of water. KIENDL (1953) has shown that there is a close correlation between the transpiration of *Phragmites* (in aquatic biotopes) and the evaporation. The transpiration was estimated to be up to 1300 l/m²/year for quantitatively well developed reed-beds at Berlin, where the yearly mean precipitation amounts to 576 mm (GESSNER 1959, p. 46). The transpiration/evaporation quotient (calculated per day) was up to 7 in late summer.

This means that in lakes overgrown with vast and quantitatively well-developed *Phragmites* reed-beds the water level conditions could be influenced by the great transpiration capability of this species (cf. RUDESCU 1965). Especially in late summer, i.e., generally at the time of the natural yearly lowest level in the waters of South Sweden, a further water level lowering could be caused in this way in lowered shallow lakes which have become overgrown with *Phragmites*.

The transpiration (per g FW and unit of time) from the upper leaves of the shoots considerably exceeded that of the lower ones (KIENDL op.c.). The difference in evaporation between the level for the lower and the upper leaves was also shown by KIENDL (op.c.). Compare also WILLER (1949, 1950) and the values for relative humidity and temperature at

the levels for the lower and upper leaves in the tables with expressed sap analyses in this paper. The best light conditions are, of course, found at the level for the upper leaves (cf. p. 214).

The upper leaves have a higher stomatal density than the lower ones and, furthermore, the upper are considerably thinner than the lower. Therefore the number of stomata per unit of weight is much greater for the upper than for the lower leaves, which could be a contributory cause to increased transpiration at the higher level.

The maximal values for the product of leaf area and stomatal density (parameters of the photosynthetic production of organic matter) were found either for the lower or the middle leaves of the shoots. Great differences occurred between clones with large-leaved and clones with small-leaved shoots.

A comparison between the biotopes 7 A and 7 C in Lake Furen shows that in one and the same clone an increase in the leaf area implies an increase in the product of leaf area and stomatal density in spite of the fact that there is a lower stomatal density in the luxuriant part (7 A) of the clone growing in the auxotrophicated biotope. However, the longest stomatal guard-cells occurred in 7 A. Compare also biotopes 19—20 Vångasjön, overgrown with the same clone (see p. 100 ff.).

On the other hand, in Norjesund the tetraploid clone in biotope 28 in spite of having smaller leaves had about the same or slightly higher products of leaf area and stomatal density as the hexaploid clones in biotopes 26—27, which here had the longest guard-cells of the stomata.

Seed Production

Investigations of seed production in *Phragmites* were presented by LUTHER (1950 a, 1950 b) and HÜRLIMANN (1951). Both authors also give comprehensive lists of references. Besides the observations referred to by LUTHER, further information from Swedish localities are given by BJÖRK (1963, 1965) and GUSTAFSSON & SIMAK (1963). All hitherto mentioned authors have also carried out germination analyses.

Under the guidance of Dr. A. SZCZEPAŃSKI extensive investigations of *Phragmites* seed production and germination are being carried out in Mikołajki, Poland. As the investigations are performed on an ecologic basis, they will be a valuable contribution to the knowledge about the possibilities of generative propagation in this species.

Data on seed production in *Phragmites* from some of the south Swedish biotopes are summarized in Table 57.

In the hexaploid types in Norjesund, which were characterized by low percentage of apparently morphologically good pollen, no well-developed, but only empty, shrunken seeds were found. No figures for seed productivity are available from the hexaploid *Phragmites* type in 30 Jägern, which had a fairly high percentage of morphologically good pollen.

According to the available material the seed production could be very variable from clone to clone in the tetraploids. On the average the lowest production in Norjesund of well-developed and the highest figures for undeveloped seeds were found in the clone in biotope 29. Of the two closely growing tetraploid clones (in biotopes 28 and 29) in Norje-

sund the biotope 29 clone also had the lowest percentage (viz. 50) of apparently morphologically good pollen. In the biotope 28 clone the percentage of good pollen was estimated to 80.

The percentage of good pollen for the clones in the other biotopes enumerated in Table 57 was: in 35 Krankesjön 89, in 41 Pukavik 93 and in 43 Löddesnäs 87.

Among the possible causes of reduced seed formation in *Phragmites* GUSTAFSSON & SIMAK (1963) mention in addition to meiotic disturbances, pollen lethality and self-incompatibility also unsuitable climatic conditions during the time of flowering and seed setting.

As mentioned above (p. 21) the pollen seems to be easily destroyed by water (rain etc.). GUSTAFSSON & SIMAK (op.c.) found in panicles collected northeast of Stockholm in 1960 77 well-developed caryopses in 3000 examined flowers and in 1962 no single well-developed caryopsis in 2700 flowers. This very poor seed setting could according to the authors possibly be due to "high rainfall and unusually low summer temperatures at the time of flowering and embryo development" (op.c., p. 447).

In a great many *Phragmites* clones in South Sweden the panicle development in 1962 was noticeably poor (cf. below, p. 207) and the flowering was poor and late (in some clones it failed), which of course affected the seed production. In 1963 the panicle development was considerably better. Thus in biotope 29 Norjesund in 31 panicles (length 17—24 cm) from 1962 only 9 (in 6 panicles) well-developed caryopses were found, while in 5 panicles (length 19—26 cm)

Table 57. Seed production in south Swedish *Phragmites* clones.

Biotope	Poly-ploid level	Date for panicle sampling	Panicles			Seeds per panicle		Sclerotia of <i>Claviceps microcephala</i>
			No.	Length cm	Weight, g (air-dried)	Well-developed	Un-developed	
26 Norjesund	6×	631030	1	20	0.43	0	0	0
			2	38	2.49	0	Numerous	1170
			3	27	1.10	0	Numerous	2
27 Norjesund	6×	631030	1	32	2.27	0	Numerous	16
			2	37	3.45	0	4522	12
28 Norjesund	4×	631030	1	30	2.44	547	0	298
			2	22	1.05	125	0	637
			3	25	1.15	298	0	289
			4	24	1.70	357	0	447
			5	20	0.83	82	0	323
29 Norjesund	4×	631030	1	23	0.68	34	8	100
			2	26	0.86	62	8	64
			3	19	0.49	5	0	50
			4	19	0.66	70	13	92
			5	24	0.88	87	13	244
35 Krankesjön	4×	641206	1	26	3.11	1395	1	474
41 Pukavik	4×	631030	1	27	1.73	55	0	1811
			2	29	1.98	559	0	257
			3	26	1.43	294	0	283
			4	25	1.74	3	0	1932
			5	27	1.21	24	0	1568
43 Löddesnäs	4×	631029	1	28	2.10	3204	0	3
			2	25	1.41	2869	2	1
			3	26	1.92	4325	4	2

from 1963 (Table 57) the number of well-developed caryopses was 258. The quotient well-developed/undeveloped caryopses was 0.05 in 1962 and 6.14 in 1963 and the quotient caryopses (well-developed+undeveloped)/*Claviceps* sclerotia was 0.04 in 1962 and 0.55 in 1963. Photographs of the two types of caryopses as well as of *Claviceps* sclerotia are found in BJÖRK (1963) and GUSTAFSSON & SIMAK (1963).

From these and other observations it could be concluded that the weather conditions directly or indirectly are of a great importance for the seed production in south Swedish *Phragmites* clones (cf. also HÜRLIMANN 1951, p. 71 ff.). The reduction of seed production caused by

Claviceps, by insects etc. has been stressed earlier by several authors.

With respect to weather conditions in regions of the world with comparatively short vegetation periods the possibilities of good seed setting are best in early-flowering clones. In panicles obtained from the marshes between the Tigris and Euphrates in Iraq, where the time of flowering and seed setting is regularly warm and dry, the seed production proved to be high (BJÖRK 1966).

For a clone in a Swiss biotope HÜRLIMANN (1951) calculated the seed production to ca. 5000 seeds/m² (20 panicles/m², 2500 flowers/panicle, 10 % of the flowers fertile).

In the biotope 43 Löddesnäs clone the

number of seeds per panicle appeared to be ca. 3000 in 1963 (Table 57). As the number of panicles was at least about 60 per m² (p. 173) the production here could be estimated to about 180000 seeds per m² in that year.

Summarizing the observations it may

be stated that the seed production could be highly variable from clone to clone and within the same clone from year to year. It has been shown here that the variation in part must be genotypically induced and that also the weather conditions are important.

Rhizomes and Roots

As for general descriptions of the rhizome and root system of *Phragmites* the reader is referred to METSÄVAINIO (1931), KAIKKO (1934), HÜRLIMANN (1951) and RUDESCU et al. (1965), and for anatomic particulars to METCALFE (1960) and the literature cited there.

Richly branched fine roots are found especially on the nodes of the upper part of vertical rhizomes. The first order roots (in the descriptions from the biotopes called "thick roots") emanating from horizontal rhizomes are relatively thick and mostly sparsely — especially those growing from the underside of the rhizomes — provided with finer roots (cf. HÜRLIMANN 1951, Fig. 13).

For most of the biotopes in this study schematic figures and descriptions in the text are given to illustrate the vertical distribution with respect to the observed highest frequencies of rhizomes and different types of roots.

The often highly complex stratigraphic conditions in the biotopes make it difficult to carry out correlations between bottom characters and the development of the plant. However, it is presumable that a considerable part of the yearly uptake of nutrients takes place by means of the fine roots developed from vertical and horizontal rhizomes close to the shoots. Planned experiments

with radioisotopes as tracers to elucidate the part played by various root types — at different levels — in the yearly uptake of nutrients have not yet been carried out. However, in manurial field experiments with sewage sludge the earlier observations made in nature have been confirmed (BJÖRK in prep.).

The vertical distribution of roots and rhizomes is highly dependent on environmental conditions.

In hard minerogenic bottoms as in biotopes 1 Fiolen and 3 Stråken the rhizomes occurred hardly lower than 20 cm in the firmly packed moraine. Strongly undulated thick and fine roots were found down to ca. 30 cm, but the frequency under 20 cm was low.

In shallow-water biotopes with soft bottoms of gyttja, clay gyttja and also clay the rhizome layer was situated mostly much deeper and the penetration depth of the roots was greater. However, in deeper water (1—2 m), as in biotopes 2 Fiolen and 17 Ängsjön, the main part of the rhizomes was fairly superficially situated. In Pukavik the rhizome and root system was so superficially situated in the loose clay gyttja that whole stands of sparse *Phragmites* were lifted to the water surface (pp. 164—165, Fig. 117).

Normally, in more or less shallow

water, the greater part of the rhizomes was found between ca. 20 and ca. 60 cm in soft bottoms. The rhizosphere of old, well-established stands has a greater vertical extension than that of young ones.

In some biotopes with gyttja, as in 19 Vångasjön, the rhizome layer was noticeably deeply situated, viz., between ca. 50 and ca. 95 cm. In other well-established tall stands in shallow water single rhizomes were sometimes found down to ca. 90 cm in soft bottoms. However, as a rule no stress was laid upon determining the maximum depth for the occurrence of single rhizomes in the different biotopes.

In bottoms consisting of a superficial layer of organogenic soils over minerogenic ones (especially when these are hard) the limit between the soil types also implies a limit with respect to the distribution of the rhizomes as the main part of these occurs in the organogenic soils. Examples of this distribution type were found in biotope 37 Björkesåkrasjön (Fig. 104) and also in 33—34 W. Ringsjön (Figs. 97—98).

In hard and coarse minerogenic soils the thick and especially the fine roots were characteristically undulated and also relatively short and hard, while they in soft, easily penetratable soils were straight, long, slender and limp. In the first soil types fine roots emanating from thick ones were found down to a depth of ca. 30 cm, in the second soil types to 100—130 cm. Between these extremes the habitus and the penetration depth of the roots varied with the soil type.

The highest frequency of fine roots was found in the superficial soil layer, where — in dense stands — a thick felt

was developed from the surface down to max. ca. 30 cm (see the schematic figures in the descriptions of the biotopes). In comparison with the amount of fine roots in the superficial soil layer the amount within and below the concentrated rhizome layer was small.

The basal nodes of shoots growing in deep water were often richly provided with bushy fine roots. This was the case in, for example, biotopes 2 Fiolen and 17 Ängsjön. The water of these lakes had the lowest electrolyte concentration among all lakes treated in this study.

In shallow water the basal nodes were rich in multibranched roots in, for example, biotopes 7 A Furen, 8 Salen, 14 Hammaren, 35 Krankesjön, 38—39 Tystrup Sö and 41 Pukavik. In manorial field experiments it has been shown (BJÖRK in prep.) that an increase in the nutrient content (perhaps in connection with decreased light intensity due to turbidity and shading) of the water stimulates root development from the shoot nodes. In, for example, 38 Tystrup Sö the light conditions at the bottom were good (low density of tall shoots). Therefore, a decrease in the intensity of light does not seem to be the only factor of importance for the node root development. Probably the supply of nutrients is the environmental parameter decisive of the occurrence of node roots in most of the mentioned shallow-water biotopes.

The effect of an addition of nutrients to a *Phragmites* stand initially is confined almost only to the area of increased nutrient addition. This indicates that only short-distance transports occur in the rhizome system. Therefore, also treatment with herbicides results in sharp limits between treated and un-

treated areas (as for absorption and translocation of plant regulators cf. VAN OVERBEEK 1956).

Examples of plaur formations with a development deviating from the common type described by, e.g., ANTIPA (1910),

PALLIS (1916), RODEWALD (1943), THUNMARK (1952) and BJÖRK (in BJÖRK & DIGERFELDT 1965), are given from the biotopes 13 Veden (p. 76 ff.) and 42 Pukavik (p. 165 ff.). See the descriptions of these biotopes.

Shoot Dimensions

The very great variation in the shoot dimensions within the area of investigation is shown in Tables 10, 11, 20, 31, 40, 43 and 51 as well as in Figs. 37, 59, 86, 108 and 133.

The clones with the smallest culm and leaf dimensions were found in the group of intact shallow-water biotopes in the oligotrophic Aneboda and Veden-Tiken-Ängsjön regions. On the other hand, the clones with the largest culm and leaf dimensions occurred within eutrophic regions. This brief scheme of the distribution with respect to size is the one included in the commonly held opinion about the development of *Phragmites* in poor and rich regions (cf., for example, GORHAM & PEARSALL 1956).

Several clones in lakes such as Stråken in the oligotrophic regions included in this investigation are characterized by having single panicle shoots of considerably greater length than the majority of the panicle shoots which are of uniform size. The reason for these great size differences in one and the same clone growing in a homogeneous environment is not known. No clone of this type is included in this study.

From the summaries of the analyses in the Analytic-Descriptive Part several constellations of shoot size and environmental conditions could be taken for illustrating the validity of the opinion that the oligotrophic regions are characterized by small and the eutrophic regi-

ons by large shoots of *Phragmites*. However, any further exemplification of this well-known fact is not given here, but some biotope—clone constellations are selected for comparison to give a more diversified view of the ecology of *Phragmites communis*.

Water Depth and Shoot Dimensions

During the different growth phases the water depth is of essential importance for shoot development and dimensions.

The buds of the next year's shoots are developed in late summer and autumn. In emerged biotopes they remain below the soil surface during winter. In shallow-water biotopes they could be some centimeters to about 1 dm long and in a deep-water biotope as 2 Fiolen many shoots are about 5 dm long already in November.

In this investigation the smallest panicle shoots in intact biotopes in oligotrophic regions were about 1 m and the largest in biotopes within eutrophic regions about 4 m, all in shallow water. However, in oligotrophic regions large shoots were found in intact deep-water biotopes. Thus the mean panicle shoot length was 3.5 m in 17 Ängsjön and shoots longer than 4 m occurred (Fig. 59). The relative length of the leaf-

bearing part of the shoots was in these cases small in comparison with that of the shoots in shallow-water biotopes. The distance between the first green leaf and the shoot top amounted to 33 % of the total shoot length in 17 Ängsjön but to 46 % in 9 B Trummen and to 54 % in 38 Tystrup Sö (all stands of tetraploid *Phragmites*, fairly sparse and with maximal and comparable number of green leaves at the time of flowering). Compare also the connection between leaf area and standing crop in Table 58.

The gradual increase in the shoot dimensions with increasing water depth and changing bottom conditions is exemplified from Lake Helgasjön in Fig. 37 and Table 11. In the outer part of the section the length of the leaf-bearing part constituted only about 20 % of the total shoot length.

For studying the effect of water level fluctuations on shoot dimensions the biotopes presented here were not very suitable. The water level fluctuations were relatively small or had a pronounced short-time irregularity. In some biotopes recorded differences in shoot length between different years could be correlated with variations in water depth. It is, however, in these cases hardly possible to select the isolated factor water depth as decisive for the differences as, for example, the temperature conditions could also have played an important rôle.

The interrelations between internode and shoot length and water depth as well as water level fluctuations during different phases of the shoot development are further described from the Danube delta by RUDESCU (1965) and also discussed by BJÖRK (1966) with respect to the growth of *Phragmites* in

the region around the Tigris and Euphrates.

Comparisons between Different Clones Growing in Similar Environment

Clones at the hexaploid level. All investigated hexaploid clones had tall panicle shoots. The comparisons here are made between clones in Norjesund. As for their distribution see Fig. 85.

Under the environmental conditions prevailing in Norjesund the mean panicle shoot length varied mostly from ca. 3.5 to 3.8 m in type A as well as in type B. The number of internodes was found to be 21 in Type A but only 17—19 in type B. Thus type A had the shorter internodes (Table 31).

There was a marked and easily observable difference in the lignification of the culms. In type A they were softer than in type B. In type A the leaves had a "soft watery tissue" (expression from STANT 1953) in comparison with type B, the leaves of which were hard. Differences in qualities of this kind have usually been considered to be dependent on environmental conditions (see TOBLER 1943 and STANT op.c.) but in the hexaploid Norjesund clones they are obviously genotypically induced. An observation of interest in this connection is that the attack of aphids was regularly much more severe in type A than in type B.

In both types the leaves were long, ca. 60 cm, but they were relatively broader in type B. The length (cm)/breadth (mm) quotient, based on the means for all leaves of the shoot (PS), was 1.4 for type A but 1.3 and lower for type B. Type A had characteristically



Fig. 137. Norjesund. Stand of the hexaploid *Phragmites* type B growing at the south shore immediately east of the new bridge (see Fig. 85). Note the flat, hanging and twisted leaves. The panicles poorly developed in 1962. — Photo S. Björk 620821.

bent-down edges of the leaves (Fig. 78), while type B had flat but dented and often twisted, hanging leaves (Fig. 137). With respect to, among other things, the characters of the leaves of the grown-out shoots the hexaploid clones were also easily separated from the tetraploid clones in Norjesund.

The occurrence of side shoots from the nodes of the middle part of the culm were not rare in the hexaploid type B.

The stability of the morphologic characters of the leaves and the shoot habitus was checked in field cultivation experiments. Rhizomes of the A and B types were planted in Lake Orlunden, close to biotope 22, and rhizomes of type B were also planted in Lake Stråken in the Aneboda region. In both lakes the bottom was minerogenic, viz., in Orlunden of the same character as in biotope 22 and in Stråken it was sandy (the total amount of extractable metallic cations ca. 35 meq/l whole soil). After 7 vegetation periods in Stråken and 3 in Orlunden the morphologic leaf characters described above had not changed. However, the shoot dimensions gradually became smaller. Panicles were devel-

oped in the first vegetation period in the new greatly different environment, but not later on.

Compared with the Norjesund types the hexaploid type in 30 Jägern, under environmental conditions different from those in Norjesund, had somewhat longer shoots. The number of internodes was ca. 20 and the internode length about the same as in type B in Norjesund. At the time of flowering the number of leaves was intermediate between the Norjesund types A and B. The absolute leaf length was about the same as in Norjesund but the relative length considerably greater; the length/breadth quotient was 1.6—1.7.

Among the three hexaploid types the yearly development and the ageing of the shoots proceed most rapidly in the Norjesund type B. In cold and rainy summers the ageing is more accelerated in this clone than in any other of all investigated clones in this study.

Clones at the tetraploid level. Instructive examples of differences in shoot dimensions between closely growing clones in similar environment are found especially in Norjesund and in the lakes Western Ringsjön and Tystrup Sö.

The clone in biotope 28 Norjesund differed from the biotope 29 clone,

growing on the opposite side of the river mouth, in having longer shoots, thicker culms and larger leaves and panicles (Fig. 86 and Tables 31—32). The number of internodes and leaves was also greater but the internode length was about the same in both clones.

In Lake Western Ringsjön the clones in biotopes 33—34 offered excellent possibilities for direct comparisons (cf. Figs. 96 and 108 and Table 43). The clone in biotope 34 had the greatest shoot dimensions with the exception of the panicles which were of about the same length in both clones. In biotope 34 the panicle shoots were about 1.5 m longer than in 33, the base diameter of the culm was nearly twice as thick, the mean internode length was 3—4 cm greater, there were ca. 4 internodes and 4—5 leaves more and the leaves were ca. 7 cm longer and 9 mm broader.

Comparable conditions were found with respect to the clones in biotopes 38—39 Tystrup Sö, where the greatest shoot dimensions occurred in the biotope 38 clone (Figs. 105 and 108 and Table 43). The difference in panicle shoot length was more than 1 m and the culm diameter in biotope 39 was only about half that in 38. In 1963, for example, the panicle length was about the same in both clones, but in 1962 the best developed panicles occurred in the biotope 39 clone. On the whole, in relation to the shoot dimensions, the best developed panicles were always found in the biotope 39 clone. The number of internodes of the panicle shoots in biotope 38 was about 30, the highest number found among all investigated clones. In biotope 39 the shoots had only

ca. 18 internodes. However, the mean internode length was about the same in both clones.

The striking differences between the clones in biotopes 41 and 41 A are seen already from Figs. 118 and 133. See also Table 51. Though no closer environmental analyses are available from 41 A, there is no reason for supposing the presence of any greater differences in the environmental conditions between the biotopes 41 and 41 A. The borderline between the clones was winding but, as also in the case of biotopes 33—34 W. Ringsjön, very sharp. The colour of the leaves in biotope 41 was dark green, in 41 A it was light green. The shoots of the clone in biotope 41 were the smallest, but they were characterized by well-developed panicles, contrasting to the small panicles in biotope 41 A. See the weight analyses in Table 52.

By these examples it is shown that a correlation between the shoot dimensions of *Phragmites* and, for example, the amounts of available nutrients could not always be taken for granted. Differences in the genetical constitution — between clones at the same polyploid level — are obviously the cause of the considerable differences with respect to the dimensions and other qualities demonstrated in clones growing close together under similar environmental conditions.

Comparisons between Parts of One and the Same Clone Growing under Different Environmental Conditions

The dimensional variation within one and the same clone is here exemplified with observations from the three biotope

groups 5—6 Helgasjön, 7 A—D Furen and 19—20 Vångasjön. All clones are tetraploid. For description of the general transition in the shoot characteristics from one biotope to another in Helgasjön see p. 50. In Lake Furen the age and the outlines of the expansion of the stand were known and in Lake Vångasjön the observations on the variability (cf. below) in and around the different biotopes confirmed the opinion of the occurrence of one single clone in each lake.

The differences in shoot size between the biotopes 5 and 6 Helgasjön (Figs. 25 and 37, Tables 10 and 12) have gradually become more evident during the last fifteen years due to the decrease in the dimensions and density of the shoots in and around biotope 5. In the oligotrophic regions of South Sweden size differences like those between the Helgasjön biotopes, though not always so pronounced, are often found in the clones in the more or less intact lakes. As in Helgasjön they often reflect differences in the bottom conditions (e.g. local deposits of fine minerogenic fractions and/or organogenic matter). In Helgasjön the highest amount of extractable metallic cations (only the superficial 50 cm soil layer analysed) was found in biotope 6, in which the largest shoots occurred. An increase in the shoot dimensions as well as in standing crop is also often found in lakes around the mouths of rivulets, where the continuous renewal of water obviously favours the quantitative development of *Phragmites*.

The biotope series 7 A—D offers an illustrative example of the increase in shoot size which takes place in biotopes

auxotrophicated by sewage (Fig. 37, Tables 10 and 12). The effect on the shoot size of an auxotrophication of this kind is restricted to a small area around the sewage outlet and there is within a distance of a few meters a marked decrease in the shoot dimensions. It should be observed that in the auxotrophicated biotope 7 A there is at present no accumulation of organic matter above the minerogenic bottom (Fig. 30). In the superficial soil layer and also on the basal nodes there is a rich development of fine roots.

In the lowered Lake Vångasjön the *Phragmites* clone with biotopes 19—20 is in a stage of expansion. From the first overgrown zone along the shore the clone is spreading lakewards over areas with other bottom conditions. The shore zone is represented by biotope 19 and a later overgrown area in a bay by biotope 20 (see p. 99 ff.).

There was a broad zone with a gradual transition from the biotope 19 area with large shoots and dark green leaves to the biotope 20 area with one meter shorter panicle shoots and yellowish green leaves (cf. Table 31). The panicles were about twice as long in biotope 19 as in biotope 20 and the panicle weight (DM) was 5—11 times greater (Table 33).

As for the soil analyses only slight differences were found between the two biotopes (Figs. 66 and 68). Somewhat higher total amounts of extractable metallic cations and of extractable Na, Mg, Ca and P were obtained from some layers in biotope 19, while the content of K was about the same in both biotopes. The greatest differences found in the available analyses between the biotopes were in the total iron content of

the interstitial water which was several times higher in 20 than in 19.

In biotope 20 the stratigraphic conditions seemed to be unfavourable to *Phragmites*, while in biotope 19 the homogeneous substratum offered better growth conditions. An accumulation of essential nutrients in the plant could probably also take place along the shore due to occasional supply of water from the ground above (cf., p. 235). The part of the clone growing in biotope 20 was excluded from such a supply.

Due to damage on the new shoots in the spring there was a decrease in the shoot size in biotope 19 in the years 1965 and 1966 (Fig. 86). In 1966 the shoot length was about the same in both

biotopes. However, the differences in leaf colour and panicle size were still the same.

A variability in the shoot dimensions of this kind is rather often met with in lakes in South Sweden (cf. also biotope 38 Tystrup Sö, p. 153). As in case of Vångasjön, when only the new shoots but not the rhizome and root system are damaged, there is usually a recovery with respect to the shoot dimensions within a few vegetation periods (cf. LOHAMMAR 1938, p. 220 ff.). However, an invasion of other hyperhydate species often results in a prolongation of the period of decreased shoot dimensions due to competition.

Panicle Frequency and Flowering Time

In biotope 1 Fiolen the panicle frequency (ca. 50 %) and the time of flowering were noticeably stable during the observation period 1954—1963 (p. 37). On the other hand, in biotope 3 Stråken variations in panicle frequency from ca. 1 to 40 % were found and the time of flowering was also variable. In part these differences could be explained by the dissimilarities in water level fluctuations in the two lakes. In Fiolen the water level is fairly stable (p. 34), but in Stråken there are considerable fluctuations (Fig. 16). In the latter part of the vegetation period the water level in Stråken could be so high that the shoots in biotope 3 were partially submerged. A long submergence implies a considerable leaching of the submerged green leaves and a decomposition of these can eventually take place. This causes a weakening of the stand which

probably results in a relatively poor panicle development the following year. In biotope 1 Fiolen conditions of this kind never occur. (However, in the deep-water biotope 2 Fiolen leaves are regularly developed from low, totally submerged shoots which, still green, are leached and decomposed.) Furthermore, due to the small water level fluctuations as well as to the topographic conditions and the supply of subsoil water the soil temperature is without doubt more stable from year to year in the Fiolen biotope than in the Stråken biotope.

According to my observations air temperature, water depth, exposition to sun and soil temperature are parameters of decisive importance for the fluctuations in the development of panicles and the time of flowering in *Phragmites*. Low air temperature and high water level in combination with shading of

the biotope during the vegetation period results in low panicle frequency and the latest time of flowering, while at high air temperature, low water level (or emergence) and exposition to sun the frequency is high and the flowering early.

Thus the earliest flowering occurs in clones growing in rapidly warmed-up shallow-water or emerged biotopes exposed to the sun as along sheltered north shores. In, for example, biotopes 8 Salen and 35 Krankesjön there was an early flowering. In slowly warmed-up biotopes there was, on the other hand, a late shoot and panicle development. As examples biotope 22 Orlunden, shaded from early in the afternoon, and the deep-water biotope 2 Fiolen are given. In 22 Orlunden the flowering was always late and in some years it failed. In 2 Fiolen the panicles never reached the stage of flowering.

In relation to the normal monthly mean air temperatures for the period May—September the following approximate values (from synoptic maps published by the Swedish Meteorological and Hydrological Institute) were found for the years 1962—1964 in the area of investigation:

	May	June	July
1962	-1.5—-2.5	-1.0—-1.5	-2.0—-3.0
1963	±0 —+2.0	+0.5—+1.5	±0 —-1.0
1964	+0.5—+2.0	+0.5—-1.0	-1.5—-2.5
	Aug.	Sept.	
1962	-2.5—-3.0	-1.0—-1.5	
1963	±0 —-0.5	±0 —+0.5	
1964	-1.0—-1.5	-0.5—-1.0	

It is seen that 1962 was characterized by temperatures considerably lower than the normal. In several of the investigated south Swedish lakes the water level was fairly high in that year. In 1963 the

temperature was higher than in 1962, in three of the months higher than normal. In 1964 the temperature was again lower than normal.

In 1962 the panicle frequency was noticeably low and the flowering late in many clones all over South Sweden and Zealand. Furthermore the panicles were poorly developed. Compare the notes about these conditions in the descriptions from the biotopes as well as the values for panicle length and weight in the tables and the representative panicles in the figures from the different regions.

In 1963 the panicle frequencies were higher and the flowering occurred earlier. Thus in 33 W. Ringsjön the increase in panicle frequency from 1962 to 1963 amounted to about 45 %, in 34 W. Ringsjön to 40 %, in 38 Tystrup Sö to 50 % and in 39 Tystrup Sö to 25 %.

Due to local deviating conditions there are exceptions from the regional characteristics of the year. This is best exemplified from biotope 15 Tiken. See Fig. 51 and the description on p. 84.

Thus, in *Phragmites* there seems to be with respect to panicle frequency and time of flowering an immediate response to the prevailing environmental conditions. No signs of cyclic variations, occurring more or less independently of the changes in the environmental conditions, have been noticed.

The fact that different clones growing in similar environment in some cases show considerable differences in panicle frequency and flowering time is demonstrable in, for example, Norjesund and Tystrup Sö.

In the hexaploid type A in Norjesund



Fig. 138. Norjesund. Panicles of the hexaploid *Phragmites* types A (left) and B. The photography taken at the border zone between the clones east of biotope 26 (see Fig. 85). — Photo S. Björk 620914.

the panicle frequency was relatively low (10—35 %), the development of the panicles often poor and the flowering occurred about one month later than in type B (Fig. 138). In this the frequency was higher (50—60 %) and the panicles usually noticeably large and well developed. Both types were growing side by side and the differences in flowering time could not be explained by differences in the temperature conditions of the bottom or in the vertical distribution of the rhizome and root system (see text and tables in Figs. 77 and 80).

Between the tetraploids in biotopes 28—29 Norjesund there were also differences in these respects. The highest panicle frequency was regularly found in biotope 28 but the earliest flowering occurred in biotope 29.

A late flowering characterized the clone in 38 Tystrup Sø in which panicle frequencies from about 20 to 70 % were noted. The clone in the closely situated biotope 39 flowered about one month earlier and the panicle frequency varied from about 55 to 80 %.

The variations due to differences in environmental conditions within one and the same clone may be exemplified from biotopes 7 A—D Furen and 19—20 Vångasjön.

The gradual increase in shoot density in the auxotrophicated biotope 7 A was accompanied by a decrease in the panicle frequency (Table 13). At the beginning of the investigation there was a thin gyttja (sewage sludge) layer over the minerogenic soil. After a cleaning outside the sewage outlet, when also a shallow groove was dug, this layer was washed away. In the latter part of the investigation the greatest influence of the sewage was at low water level in summer. Latent buds were then stimulated to shoot development. This caused a lower panicle frequency than at the beginning of the investigation, when the presence of the sewage sludge layer provided more stable environmental conditions during the whole vegetation period. The observations in Furen correspond to those made in field manurial experiments.

The increase in panicle frequency in biotopes 7 C—D is probably a result of the stabilization of the stand in its younger parts.

The biotopes 19—20 in the Vångasjön clone showed regularly great differences with respect to panicle frequency. In biotope 19, in the luxuriant part of the stand close to the shore, it was regularly high, viz. 90 %, while it was only about 10 % in biotope 20. The difference has evidently environmental causes.

Obviously low panicle frequencies in *Phragmites* could often be correlated with small amounts of available nutrients.

In biotope 5 Helgasjön there was no panicle development in all years of observation. Among the characteristics of this biotope was the low total amount of metallic cations extractable from the sand, viz., only about 25 meq/l. Amounts of this order were also obtained from comparable soils in biotopes 10 Rolsmsjön and 16 Ängsjön where, however, fairly high panicle frequencies could be found. However, in both of the last-mentioned biotopes there were indications of a continuous supply of subsoil

water. As such a supply obviously was lacking in 5 Helgasjön, there seemed to be more favourable environmental conditions in the two other biotopes, which might have been the cause of the higher panicle frequency there. Lacking results from cultivation experiments the question of genotypically caused differences in panicle frequency must in these as in all other cases of comparisons between separate clones growing in different environments be unanswered.

Shoot Density

The lowest shoot densities, of the order of 2—20, were found in the intact biotopes in the oligotrophic regions, and the highest, more than 200, in some of the coastal biotopes. In both types of biotopes the shoot size was small.

In stands of large shoots with thick culms the density was relatively low. In freshwater biotopes with stands of high shoot densities the shoots had thin culms. See the tables with biometric analyses. Compare also OLSEN 1945.

Comparisons are here again made between different clones growing in similar environment. As for the hexaploid types A and B in Norjesund no significant differences in shoot density were found. However, between the tetraploid clones in biotopes 28—29 Norjesund there was regularly a distinct difference in shoot density; the density of the larger shoots in biotope 28 varied from 60 to 90 and of the slender shoots in biotope 29 from 100 to 130.

The clones in 33—34 W. Ringsjön and 38—39 Tystrup Sö are also in this respect excellently well suited for comparisons.

The density of relatively small shoots in biotope 33 varied from 90 to 130, and that of the tall shoots in biotope 34 was about 45. In the stand of tall shoots in 38 Tystrup Sö the density was 35, while it was 70 in the biotope 39 stand of considerably smaller shoots.

For exemplification of the density variation within one and the same clone the conditions in the earlier treated clones in 5—6 Helgasjön, 7 A—D Furen and 19—20 Vångasjön are again used.

In the sparse stand in which biotope 5 Helgasjön was situated, there was a retreat in the density from ca. 25 to ca. 15 during the period 1951—1964, while in biotope 6 it was about 45 during the same period.

In its initial stage an auxotrophication with sewage like that in 7 A Furen causes a marked increase in the shoot density. Provided that the clone is of a type with the ability to produce large shoots there is later on, usually after the development of an organogenic layer over the minerogenic soil, a reduction of the density at the same time as the shoot size becomes

larger. In connection with this there is a reduction of the number of shoots without panicles (the panicle frequency increases).

In biotope 7 A Furen the outlined progress was disturbed by the cleaning mentioned above, but in, for example, the auxotrophicated biotope 4 Stråken the stand had reached a more or less stabilized stage which is characterized by larger shoots with moderate density but fairly high panicle frequency. In clones expanding over gyttja bottom in lowered lakes the stabilization takes place inside the marginal zone. The biotopes 8 Salen, 9 B Trummen and 32 Tåkern are situated in the inner stabilized parts of such clones.

The density of the Vångasjön clone varied from ca. 45 in biotope 19 where the shoots were large and thick to ca. 95 in biotope 20 where the shoots were short and slender.

Observations in the coastal biotopes 45 A—C Bjärred and 46 Praestö Fjord seem to indicate that labile conditions in the superficial part of the rhizosphere, such as periodical emergence and influence of frost and ice, could cause an increase in the shoot density as latent buds are stimulated to development. If the very young shoots ("next year's shoots") are destroyed in spring, this often causes a development of shoots from a proportionally greater number of

latent buds. (In large-grown *Phragmites* types as those found in 34 W. Ringsjön and 38 Tystrup Sö this has, however, not been observed.) No panicles are developed on these relatively shorter shoots. Thus, as a result of the destruction of the original young shoots the density can become greater and the panicle frequency lower. Also an occasional increased supply of nutrients causes a development of latent buds (compare p. 208 with respect to biotope 7 A Furen).

Among the auxotrophicated biotopes within the Veden-Tiken-Ängsjön region the stands in biotopes 11 Rolsmosjön and 14 Hammaren* consisted of large shoots with a density of about 60—70, thus contrasting to the stands in 12 Linne-rydssjön, 13 Veden and 15 Tiken, where the shoots were smaller (slender culms) but the density amounted to 100—140. It is difficult to explain these differences without testing the clones in similar environment. However, it is possible that the high density also in these cases is partly dependent on the instability of the environmental conditions in the upper part of the rhizosphere, due to occasional emergence in biotopes 12 and 15, and plaur-like formation in biotope 13. In the plaur biotope 42 Pukavik the accumulation of dry stems evidently obstructed the development of the new shoots. Along the margin of the plaur there was a zone with considerably higher density.

Standing Crop and Leaf Area

Neither the *Phragmites* shoot dimensions nor the shoot density could be used as parameters for judging the productivity in comparative studies of clones and biotopes. In an attempt to make comparative estimations of the productivity the

figures for standing crop (DM, g/m²) and the figures for total area of the green leaves (dm²/m²) included in the standing crop are put in relation to each other in the quotient standing crop/leaf area. See Table 58, p. 213.

The absolute values for leaf area range from ca. 5—20 dm² in the intact biotopes (1, 1 A—B, 2, 3, 5, 16 and 18) characteristic of oligotrophic regions to the maximal value 800 dm² in 36 Krankesjön in the group of biotopes within eutrophic regions. Regionally high values (ca. 100 dm²) were found in 6 Helgasjön and 17 Ängsjön and regionally low (ca. 125 dm²) in 35 Krankesjön.

As figures for leaf area are not available from more than one hexaploid and one tetraploid clone in Norjesund and from none of the clones in Tystrup Sö (the outer parts of many leaves broken), the comparisons with respect to leaf area between different clones growing in similar environment are restricted to biotopes 33—34 W. Ringsjön. The area here was found to be slightly larger in the biotope 34 clone with tall shoots and low density than in the biotope 33 clone characterized by lower shoots and a density about twice that in 34.

The variation in leaf area between different parts of the same clone is exemplified from 5—6 Helgasjön, 7 A—D Furen and 19—20 Vångasjön. In 6 Helgasjön the area was about 7 times as large as in 5 Helgasjön. The quotients between the leaf area in biotope 7 A (auxotrophicated by sewage) and the areas in the closely situated biotopes 7 B, 7 C and 7 D were 4.5, 4.6 and 3.2 respectively. As for the biotope group 19—20 Vångasjön leaf area values are available from three years (1962—1964). The largest area was always found in biotope 19 and the quotients between the areas in 19 and 20 were 2.1, 3.3 and 1.8 for the mentioned years.

In most of the biotopes in eutrophic regions the leaf area was calculated to be of the order of 300—600 dm²/m². How-

ever, about the same areas were also found in clones in several auxotrophicated biotopes (11, 12, 13 and 19) in the oligotrophic regions. Furthermore, in one of these, viz., 8 Salen, the area was about 800 dm², i.e., the area was here comparable with the largest one found in the group of biotopes within eutrophic regions.

The absolute values for standing crop range from ca. 10—65 g in intact biotopes characteristic of oligotrophic regions to somewhat above 2000 g in biotopes in eutrophic regions.

As for the hexaploid clones in Norjesund the available data on standing crop are not sufficient for judging whether there were true differences between the clones growing in similar environment. However, with respect to the tetraploid clones there were significant differences. From the clones in biotopes 28 and 29 determinations were made in 1962 and 1963. According to these the standing crop in biotope 29 amounted to only ca. 55 and ca. 65 %, respectively, of that in biotope 28.

In 33—34 W. Ringsjön the higher values for standing crop were obtained in the fairly sparse stand of large shoots; in 1962 only 10 %, but in 1963 ca. 30 % higher values were found. As already pointed out, there were considerable differences in weather and water level conditions between the two years.

While the standing crop in 39 Tystrup Sö was fairly stable during the period of observations, great irregularities in the quantitative development were registered in biotope 38 (cf. pp. 153 and 206). Thus, in 1962 the obtained figures for standing crop were about the same in both biotopes, while in 1963 the value for 38 was

about 35 % higher than that for 39. Variations in standing crop from year to year were found also in other biotopes. This was easily observable especially in the homogeneous stands in 12 Linnerydsjön, 19—20 Vångasjön, 33—34 W. Ringsjön and 41 Pukavik.

Variations in standing crop within the same clone (in the same year) are illustrated by the figures from the biotopes 5—6 Helgasjön, 7 A—D Furen and 19—20 Vångasjön. See Table 58.

Among the environmental factors considered to be of importance for the quantitative development of *Phragmites* are the physical bottom conditions. As pointed out by several authors (cf., LUTHER 1951) and also shown in this study, the quantitative development of *Phragmites* is often good when it grows in gyttja. On the whole, a loose bottom substratum is easily penetrable for the rhizomes and roots and the rhizosphere includes a large volume of soil. On the other hand, a hard minerogenic soil is obstructive for the development of the rhizomes and roots.

With a perennial plant such as *Phragmites communis* it is often difficult to judge the trophic state of it from soil and water analyses as well as to make correlations between these and the quantitative development of the plant (cf. below p. 234 ff.). However, the conditions in the biotopes 18 Vitavatten (Fig. 64) and 19 Vångasjön (Fig. 66) are recalled here as illustrations of the variation in different gyttja types. The biotope 18 gyttja was characterized, among other things, by very low content of extractable P and also of K. In biotope 19 the content of P was about 10 times as high and that of K about twice as high. On the other hand, the amounts of Mg and Ca were higher

in biotope 18. The standing crop relation between biotopes 18 and 19 was about 1 to 80. The conditions in 22—23 Or-lunden may also be compared. In this case there was a marked increase in the standing crop from the pure minerogenic bottom to the border zone minerogenic—gyttja bottom. In this case the gyttja had a higher total amount of extractable metallic cations, but a considerably lower concentration of K than the minerogenic soil.

The effect of auxotrophication on the productivity of the *Phragmites* stands is illustrated especially well by biotopes 4 Stråken, 7 A—D Furen, 8 Salen and 9 A—B Trummen and also by 11 Rolsmosjön, 12 Linnerydsjön, 13 Veden, 14 Hammaren, 15 Tiken and 19 Vångasjön. Three different types of auxotrophication are included here, viz., lowering of the water level, discharge of sewage and discharge of industrial waste-water. Though no analyses of N and but few of P are available, it can be taken for granted that in several of the auxotrophicated biotopes the increase in the available amounts of these elements plays a considerable rôle in the quantitative increase of *Phragmites*. Concerning the importance of N the reader is referred to MISRA (1938) and HÜRLIMANN (1951). In biotopes auxotrophicated by sewage (e.g., 4 Stråken, 7 A Furen and also in parcels manured with sewage sludge) *Phragmites* is not as stiffed-strawed as in most other biotopes. Probably this is a result of a rich uptake of N.

In the auxotrophicated biotope 4 Stråken the standing crop was about 20 times that in the fairly intact biotope 3 Stråken. In 11 Rolsmosjön it was about 25 times that in 10 Rolsmosjön; the lowering of Rolsmosjön caused an auxo-

Table 58. The connection between standing crop and leaf area with respect to clones, biotopes and years.

Biotope	Year	Shoot density	Panicle frequency %	A Standing crop g/m ²	B Leaf area dm ² /m ²	A/B	Biotope	Year	Shoot density	Panicle frequency %	A Standing crop g/m ²	B Leaf area dm ² /m ²	A/B
1	63	18	42	48	16	3.0	22	63	21	76	121	42	2.9
1 A	62	10	63	23	7	3.3	22—23	63	40	68	299	65	4.6
1 B	62	11	61	42	16	2.6	23	63	27	15	210	51	4.1
2	62	4	0	40	12	3.3	26	63	62	29	1630	592	2.8
3	61	15	36	30	11	2.7	27	63	56	63	1934	.	.
3	62	21	1	26	9	2.9	27 C	63	51	67	1842	.	.
4	62	35	53	568	204	2.8	28	62	79	56	1785	.	.
5	64	14	0	39	14	2.8	28	63	69	72	1657	.	.
6	64	39	3	311	103	3.0	29	62	111	45	954	425	2.2
7 A	64	135	46	541	281	1.9	29	63	107	46	1100	488	2.3
7 B	64	82	73	226	63	3.6	30	63	27	63	929	282	3.3
7 C	64	85	89	280	61	4.6	32	62	58	71	1419	.	.
7 D	64	88	85	372	88	4.2	32	63	82	66	1403	387	3.6
8	64	87	53	1782	771	2.3	33	62	126	25	1454	.	.
9 B	64	31	87	1278	.	.	33	63	96	68	1674	524	3.2
10	63	14	39	65	16	4.1	34	62	50	38	1579	.	.
10	64	15	4	35	11	3.2	34	63	42	82	2210	581	3.8
11	63	59	74	1208	419	2.9	35	64	25	86	504	126	4.0
12	62	131	74	994	334	3.0	36	63	136	79	2381	807	3.0
12	64	116	41	791	392	2.0	37	64	53	64	1214	291	4.2
13	63	132	65	1377	606	2.3	38	62	29	18	1329	.	.
14	63	53	81	975	.	.	38	63	41	74	2197	.	.
15	63	115	7	563	168	3.4	39	62	75	55	1350	.	.
15	64	92	42	521	217	2.4	39	63	61	79	1471	.	.
16	63	18	66	52	14	3.7	40	62	116	52	1468	455	3.2
17	63	24	25	491	99	5.0	41	63	75	61	1254	.	.
18	62	2	0	11	4	2.8	41	63	111	78	1718	517	3.3
19	62	40	90	793	312	2.5	42	62	84	5	979	.	.
19	63	57	91	1080	334	3.2	43	63	85	75	1231	.	.
19	64	42	90	793	241	3.3	44	63	92	90	903	194	(4.7)
20	62	103	7	382	156	2.4	46	63	178	59	957	331	2.9
20	63	90	6	328	122	2.7		63					
20	64	83	16	438	161	2.7							

trophication in the area with biotope 11, while the area with biotope 10 was only slightly affected.

As for the standing crop/leaf area quotient the mean of the available figures from all clones and biotopes is 3.2 (Table 58).

Among the couples of different clones growing in similar environment quotients are available only from 33—34 W. Ringsjön. In comparison with the dense stand in 33 W. Ringsjön the sparse stand in the closely situated biotope 34 showed a greater dry matter amount per leaf area. The quotients were 3.2 and 3.8 respectively.

The environmentally induced variation within the same clone is analysed in 5—6 Helgasjön, 7 A—D Furen and 19—20 Vångasjön. In Helgasjön the standing crop/leaf area quotient was somewhat higher in the part of the stand with biotope 6 in which the shoots were relatively tall but the density not higher than ca. 40 (1964). On the other hand, in Furen a low quotient (1.9) was found in the 7 A biotope, while in 7 B—D the quotients were high (3.6—4.6). As for biotopes 19—20 Vångasjön there were in all three years of investigation a difference between the two sampled parts of the clone. The higher quotients were always found in biotope 19.

The differences found between different years in one and the same clone could — at least in part — be correlated with variations in weather and water level conditions. Compare, for example, 19—20 Vångasjön.

It is a pervading characteristic that no high standing crop/leaf area quotients were found in stands with high shoot density. It should be pointed out that the

quotients in these cases actually are often a little too high because the leaf shedding starts earlier in denser than in sparser stands. The quotient for 44 Lödösnäs is in this respect an extreme as the lower leaves here became yellowish early in the summer. The reason for the lower standing crop/leaf area quotient in denser stands is probably to be found in the shading of the middle and lower leaves.

The biotope series 7 A—D is mentioned here again as it offers an illustrative example of the variation in this respect. In the dense part of the stand in 7 A (auxotrophicated by sewage, cf. p. 51 ff.) the lowest quotient, viz. 1.9, was found. However, for the taller, shading panicle shoots the ratio was 2.1, while for the smaller, shaded shoots without panicles it was 1.6. In the sparser part of the stand with biotopes 7 B—D the quotients were considerably greater. Compare also the figures for 35—36 Kranke-sjön.

Between the dimensionally highly different clones in 16—17 Ängsjön there was also with respect to the standing crop/leaf area quotient a great difference. In biotope 16 a leaf area of 1 dm² corresponded to 3.7 g dry matter, but in biotope 17 to 5.0 g, the highest figure found in the whole investigation. It was pointed out above (p. 201—202) that the leaf-bearing parts of the shoots are relatively small in deep-water biotopes (compare the shoots from 2 Fiolen and from the outer part of the reed-bed in Helgasjön in Fig. 37 as well as from biotope 17 in Fig. 59). Thus, in these cases a small leaf area corresponds to a relatively large amount of dry matter. However, it should also be pointed out that the time of development of these shoots is rela-

tively longer than that of the shallow-water shoots (cf. p. 201), and that the photosynthetic activity of the stem and the sheaths are, without doubt, responsible for a greater dry matter production in deep-water than in shallow-water biotopes. As the areas of the stems and the

sheaths have not here been included in the photosynthetic active area (cf. STÖY 1965), the standing crop/leaf area quotients for deep-water biotopes are somewhat too high and not exactly comparable with those obtained for the shallow-water biotopes.

Expressed Sap and Press-Cake

For evaluating the ecologic validity of the analyses of expressed sap the suitability of the method for *Phragmites* is tested and the obtained analytical material treated according to the aspects presented in the following five subheads. Reference is made here to the analyses in Tables 15, 23, 24, 34, 35, 44, 45, 54 and 55.

The investigations in the coastal biotopes were included in this study mainly with the intention of making comparisons with the stands in the freshwater biotopes with respect to element uptake and osmotic potential. The response of the plant to the great environmental differences between the coastal and the freshwater biotopes was presumed to provide a good background for the judging of the comparatively smaller differences within the group of freshwater biotopes.

1. *The Distribution of Elements on Expressed Sap and Press-Cake*

Material for comparisons with respect to the distribution is presented in Table 59 from the biotopes 15 Tiken, 19—20 Vångasjön and 41 Pukavik. The Tiken analyses represent a day series. From the two Vångasjön biotopes and the Pukavik biotope analyses from different parts of the vegetation period are included.

In all samples press-cake as well as expressed sap were analysed and the distribution by percentage calculated from the sum of these.

From the Tiken analyses it is seen that in a homogeneous plant material (in this case samples of leaves of equal age and size and with equal insertion level collected with short time intervals) there is a good conformity between the different samples in the element distribution on press-cake and expressed sap. However, it is also seen that the distribution differs in upper and lower leaves. The amount of Na, K, Mg and Ca retained in the press-cake is greater in the upper leaves which are harder than the lower ones.

It appears also from the analyses from the other biotopes that in shoot parts of comparable age and with comparable insertion level, there is a tolerable uniformity in the percentage distribution on press-cake and expressed sap of the analysed elements.

The most stable conditions are found when the shoots are fully developed. The great majority of the samples in this investigation were sampled during this period, viz., from panicle development to flowering.

As for the leaves, deviations from the distribution characteristic of the full-grown stage were found in the beginning

Table 59. The seasonal variation in the percentage distribution of elements on expressed sap and press-cake in rhizomes and different shoot parts. Material from the biotopes 15 Tiken, 19—20 Vångasjön and 41 Pukavik. PC=press-cake, ES=expressable sap.

Shoot part	Bio- tope	Sample no.	Date	h	Na		K		Mg		Ca		Fe	
					PC	ES	PC	ES	PC	ES	PC	ES	PC	ES
Rhizomes	19	22/63	630530	17.30	46	54	47	53	85	15	20	80	.	.
		58/63	630628	14.00	39	61	40	60	45	55	26	74	74	26
		115/63	630805	17.00	46	54	47	53	54	46	37	63	81	19
		180/63	630921	15.00	46	54	47	53	51	49	37	63	76	24
	20	218/63	631030	11.30	50	50	50	50	57	43	31	69	83	17
		24/63	630530	18.30	46	54	50	50	73	27	20	80	.	.
		62/63	630628	16.00	46	54	48	52	51	49	34	66	73	27
		117/63	630805	19.00	45	55	48	52	55	45	29	71	72	28
	41	174/63	630919	17.30	51	49	51	49	52	48	28	72	71	29
		220/63	631030	13.30	54	46	54	46	62	38	38	62	81	19
		20/63	630530	14.30	36	64	40	60	75	25	11	89	.	.
		30/63	630617	12.30	35	65	33	67	40	60	22	78	63	37
	41	146/63	630817	14.00	38	62	39	61	44	56	28	72	79	21
		201/63	630928	11.30	33	67	33	67	45	55	22	78	85	15
		221/63	631030	14.00	41	59	42	58	48	52	32	68	83	17
Lower leaves	15	51/64		6.00	27	73	28	72	32	68	39	61	94	6
		53/64		9.00	27	73	25	75	32	68	38	62	96	4
		55/64	640815	12.00	26	74	26	74	35	65	43	57	95	5
		57/64		15.00	27	73	25	75	35	65	39	61	95	5
		59/64		18.00	25	75	24	76	32	68	40	60	96	4
		61/64		21.00	30	70	30	70	40	60	43	57	95	5
	19	55/63	630628	14.00	27	73	17	83	28	72	32	68	97	3
		113/63	630805	17.00	26	74	18	82	26	74	34	66	98	2
		178/63	630921	15.00	23	77	23	77	28	72	34	66	97	3
	41	28/63	630617	12.30	15	85	19	81	22	78	33	67	94	6
		145/63	630817	14.00	18	82	21	79	29	71	48	52	94	6
		200/63	630928	11.30	24	76	28	72	36	64	46	54	98	2
Upper leaves	15	50/64		6.00	40	60	31	69	41	59	43	57	93	7
		52/64		9.00	38	62	30	70	39	61	41	59	94	6
		54/64	640815	12.00	37	63	32	68	39	61	44	56	95	5
		56/64		15.00	39	61	31	69	39	61	44	56	95	5
		58/64		18.00	48	52	30	70	40	60	43	57	95	5
		60/64		21.00	40	60	30	70	39	61	42	58	94	6
	19	21/63	630530	17.30	18	82	16	84	55	45	25	75	.	.
		56/63	630628	13.30	48	52	22	78	35	65	45	55	96	4
		112/63	630805	16.00	40	60	26	74	37	63	47	53	98	2
		177/63	630921	14.00	35	65	27	73	37	63	39	61	98	2
		217/63	631030	11.00	35	65	36	64	44	56	55	45	99	1
		23/63	630530	18.00	29	71	22	78	49	51	37	63	.	.
	20	60/63	630628	16.00	39	61	24	76	37	63	44	56	96	4
		116/63	630805	18.00	55	45	32	68	47	53	55	45	98	2
		172/63	630919	16.30	37	63	32	68	41	59	52	48	97	3
		173/63	630919	17.00	43	57	36	64	45	55	53	47	97	3
		219/63	631030	12.30	47	53	49	51	52	48	57	43	98	2
		19/63	630530	14.30	14	86	16	84	38	62	28	72	.	.
Panicles Shoot tips	41	29/63	630617	12.00	19	81	20	80	31	69	41	59	94	6
		143/63	630817	13.00	29	71	29	71	45	55	54	46	97	3
		198/63	630928	11.00	32	68	33	67	42	58	48	52	98	2
	19	234/63	631030	.	100	.	100	.	100	.	100	.	100	.
		57/63	630628	13.30	24	76	16	84	29	71	35	65	97	3
		61/63	630628	16.00	24	76	20	80	30	70	54	46	85	15
	41	114/63	630805	16.00	33	67	25	75	37	63	36	64	98	2
		179/63	630921	14.00	67	33	71	29	75	25	78	22	99	1
		144/63	630817	13.00	30	70	28	72	43	57	42	58	92	8
		199/63	630928	11.00	65	35	71	29	78	22	77	23	99	1

Table 60. Analyses of expressed sap from rhizomes and different parts of shoots from the clone in biotope 38 Tystrup Sö 630831. See also Table 44.

Sample no.	Shoot part	W1 % of FW	ES ml/kg FW	A2 % of A1	A3	O ₂₀ atm	Sp. cond. mS	pH	Na	K	Mg mmol/l	Ca	Fe	Cl
151/63	Rhizomes	80.2	594	37.7	62.3	11.6	13.7	5.2	4.9	142	5.5	2.4	0.07	92
149/63	Lower leaves	67.1	577	44.0	56.0	23.3	28.2	5.5	4.0	247	50	140	0.05	243
148/63	Upper leaves	55.0	437	68.6	31.4	24.2	15.3	5.8	2.4	141	59	85	0.04	136
150/63	Panicles	71.9	587	46.3	53.7	15.2	14.7	5.7	7.2	144	18	20	0.04	71

and at the end of the vegetation period. The content of Na and K in the press-cake was approximately correlated with the content of water, i.e., roughly the unexpressed sap fraction. The same correlation could be expected for Cl.

2. The Variation in Expressed Sap Quality within the Plant

The variation between different parts of the plant in expressed sap qualities is exemplified in Table 60, excerpted from Table 44. The material was obtained from about 4 m long shoots with panicles grown out to about 95 % but not yet flowering. The distribution type is in most respects characteristic of *Phragmites* at this stage of development. However, in short shoots the differences between upper and lower leaves usually are not as accentuated as in this case.

The lowest water content and the lowest amount of expressable sap was obtained from the upper leaves. The expressed sap contained slightly more than half the total ash content of the whole plant material at all sampled levels except in the upper leaves where the sap ash content was lower. The osmotic potential was low in sap from the rhizomes and from the panicles. In the leaves it was considerably higher. A high value for the specific conductivity was found in the sap from the

lower leaves. At the other levels it was much lower and the values were about the same for the sap from all three parts of the plant. The lowest pH was obtained from the rhizomes and the highest from the upper leaves.

The concentration of Na was in this case rather low at all levels. In the clones in biotopes in fresh waters the highest values were found mostly in the rhizomes and sometimes the concentration could be considerable in panicles during and past flowering (rapid ageing).

The distribution of K was not quite typical. The difference between the lower and the upper leaves is usually not as great as in the biotope 38 Tystrup Sö clone. In these tall shoots the concentration of K at both of the upper levels was comparatively low.

As for Mg and Ca there were the characteristic great differences between the low content especially in the rhizomes but also in the panicles and the high concentration in the leaves; the concentration of Ca was highest in the lower (oldest) leaves.

It has been shown by CHAPMAN (1960) that a variation in the content of Cl could be found between different levels of the rhizomes and stems in *Phragmites*. The proportions between Na and Cl could also be variable. This is clearly shown also in Table 60.

In the shoots in 38 Tystrup Sö the distribution of Cl resembled that of K. The concentration (on equivalent basis) was many times that of Na.

Summing up the facts about the sap quality variation within the plant it is concluded that there can be great differences between various parts of the plant. When making comparisons between different clones and biotopes the comparisons must be based on well defined samples from homologous rhizome and shoot parts.

3. Daily Variation in the Expressed Sap Quality

The variation during the day in the osmotic potential is well-known from investigations on various plants. Compare, for example, WALTER & WALTER (1929), STODDART (1935), MÜLLER-STOLL (1938), ADRIANI (1945) and TAKADA (1951, 1954).

In Fig. 140 the variation in expressed sap qualities during one day is illustrated with respect to the *Phragmites* clones in biotopes 15 Tiken and 43 Löddesnäs. Environmental characteristics are given in the diagram series in Fig. 139. Compare also the photographs of the biotopes in Figs. 51 and 124.

On the sampling occasion the bottom in 15 Tiken was emerged; subsoil water level about 20 cm below soil surface.

In 43 Löddesnäs the biotope was emerged in the morning of the sampling day. Water sampling was then performed in a dug pit. Later on there was a rise in the water level and the biotope was submerged by water of higher salinity than that in the dug pit.

In Tiken the water quality was stable. In Löddesnäs there were considerable

variations, typical of a coastal biotope like this. The rise in water level and the supply of more saline water brought about a rise in the concentration of especially Na, K and Cl and also of Mg, but a marked decrease in the concentration of P and a slight decrease in Ca. Samplings were performed in the biotope and in a site 3 m outside this, in the margin of the *Phragmites* stand (see Figs. 123 and 124).

At the 6 a.m. sampling there was dew on the leaves in Löddesnäs but not in Tiken. In Löddesnäs the sampled leaves were then rapidly and carefully dried with absorbent paper. The highest air temperature and the lowest relative humidity as well as the greatest amplitudes for these factors during the day were recorded in Löddesnäs with respect to the levels for both the upper and the lower leaves.

The analyses of expressed sap (Fig. 140) comprised the three upper and the three lower leaves in both biotopes. As for insertion levels and leaf dimensions see Tables 24 (samples 56/64 and 57/64) and 55 (samples 90/63 and 91/63). In Löddesnäs also rhizome sap was analysed (Table 55, samples 89/63, 93/63 and 96/63). Press-cake analyses from Tiken are included in Tables 23 and 59.

There was a marked increase in the osmotic potential from the first to the third sampling in Löddesnäs. Here the highest values were found in the upper leaves, where the maximum was obtained at 3 p.m. Probably due to the more unstable weather conditions (considerable changes in light intensity) the course of the curves for Tiken does not have the same regularity with a marked

afternoon maximum as in Lödösnäs. The difference between the lowest value for the morning and the highest in the afternoon amounted to 7.4 atm in the upper leaves in Lödösnäs. In Tiken it was 6.1 atm. WALTER & WALTER (1929) found a difference of 2.2 atm between morning and afternoon samples in leaves of *Phragmites* collected in Tihany (Hungary). WALTER (1951, p. 283) considered this difference as "für Sumpfpflanzen ausserordentlich hoch".

In the diagrams the curves for the osmotic potential are almost reflected images of those for the water content of the leaves (W 1, in per cent of FW). However, the increase in osmotic potential during the day was relatively greater than the lowering in water content. This indicates that a rich formation of osmotically active substances (saccharides) takes place. (Unfortunately no analyses of saccharides were carried out. Cf. p. 10.)

With respect to the sap content of Na, K and Cl there was also a concentration increase greater than the corresponding decrease in water content of the expressed sap as well as of whole plant material. This is true for Tiken as well as for Lödösnäs. However, the values for specific conductivity were about the same on all sampling occasions in the respective biotopes.

The best defined plant material consists of the upper leaf samples. From these the most even values were obtained. With respect to the lower leaves there is a greater irregularity in the analyses, in part probably due to variations in the quality of the plant material. The equivalence in leaf age, light intensity and other environmental conditions

is not as good for the lower as for the upper leaves.

In Lödösnäs there was during the day an increase in the specific conductivity and in the concentrations of Na, K, Mg and Cl in the lower leaves. As the variations in the water content of the expressed sap were small, a correlation with the changes in the environmental conditions at a hasty glance does not seem to be totally excluded. However, the variations were without doubt mainly due to differences in the plant material. The relatively low content of Ca in the sap of the first sample and the higher content in that of the second and third samples indicate that the leaves in the first sample were relatively younger than in the two other ones.

The differences in element concentration inside and outside the plant in the two biotopes may be noted and also the differences in the element enrichment in the two clones. See further below under subhead 5.

Judging from the observations on the daily variation in the expressed sap quality it is concluded that the variations in osmotic potential can be considerable. The increase in the concentrations of elements from, for example, the first samples in the morning to the time for the highest osmotic potential in the afternoon was greater than the decrease in water content determined on these occasions. The specific conductivity was, however, about the same during the whole day.

In a regional-limnologic study it is difficult to carry out the samplings of plant material at a fixed time of the day and under similar weather conditions. As far as possible the samples were taken in early afternoon.

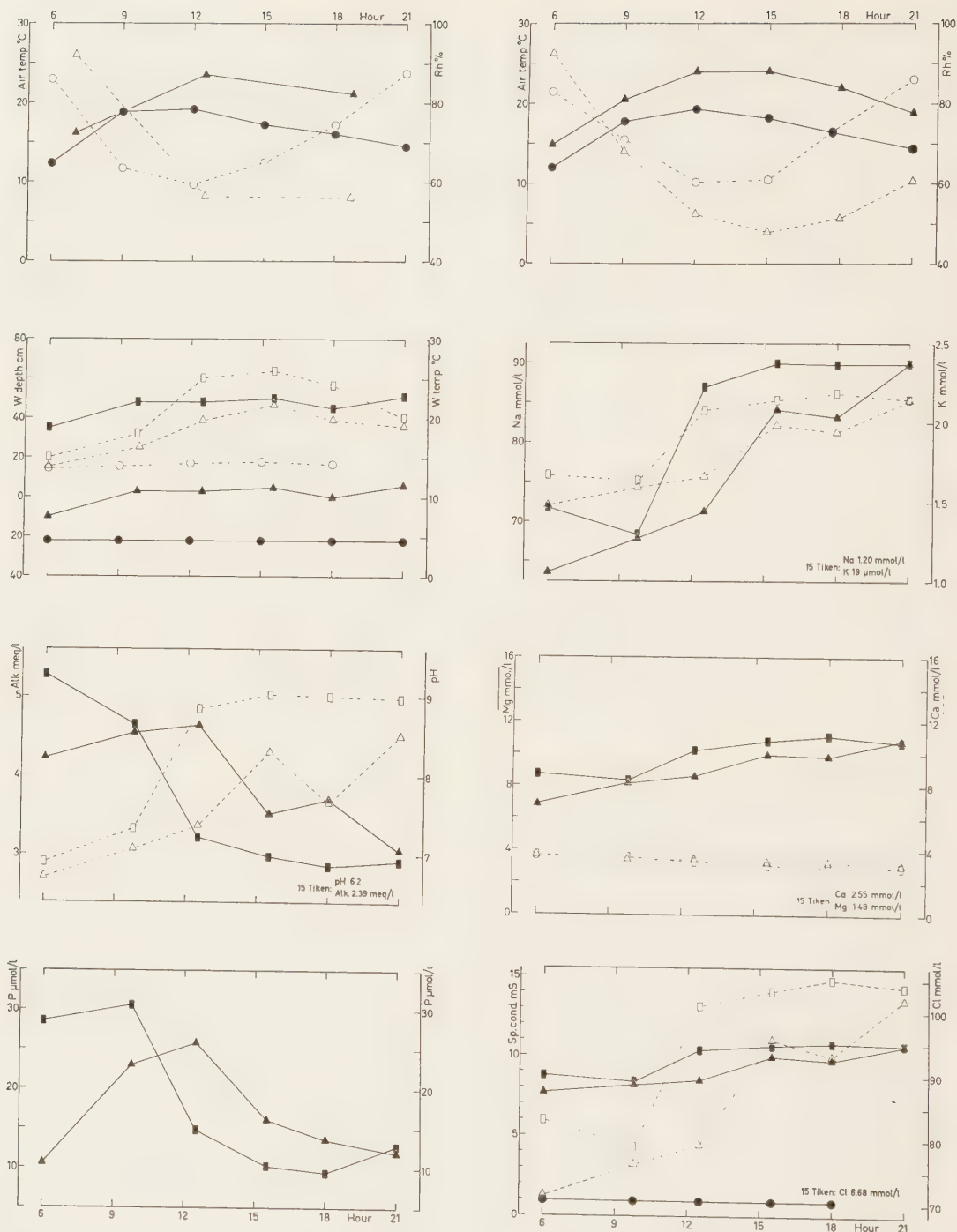


Fig. 139. Environmental conditions during one day in biotopes 43 Lödösnäs 630723 and 15 Tiken 640815. Water analyses from the reed-bed margin in Lödösnäs also included (cf. Figs. 123 and 124). Top left air temp. and Rh at the lower margin in Lödösnäs also included (cf. Figs. 123 and 124). The other diagrams refer to the water. Symbols: Triangle=43 Lödösnäs; rectangle=reed-bed margin Lödösnäs; circle=15 Tiken. Left axis factors indicated by solid lines and symbols, right axis factors by broken lines and open symbols (P excepted).

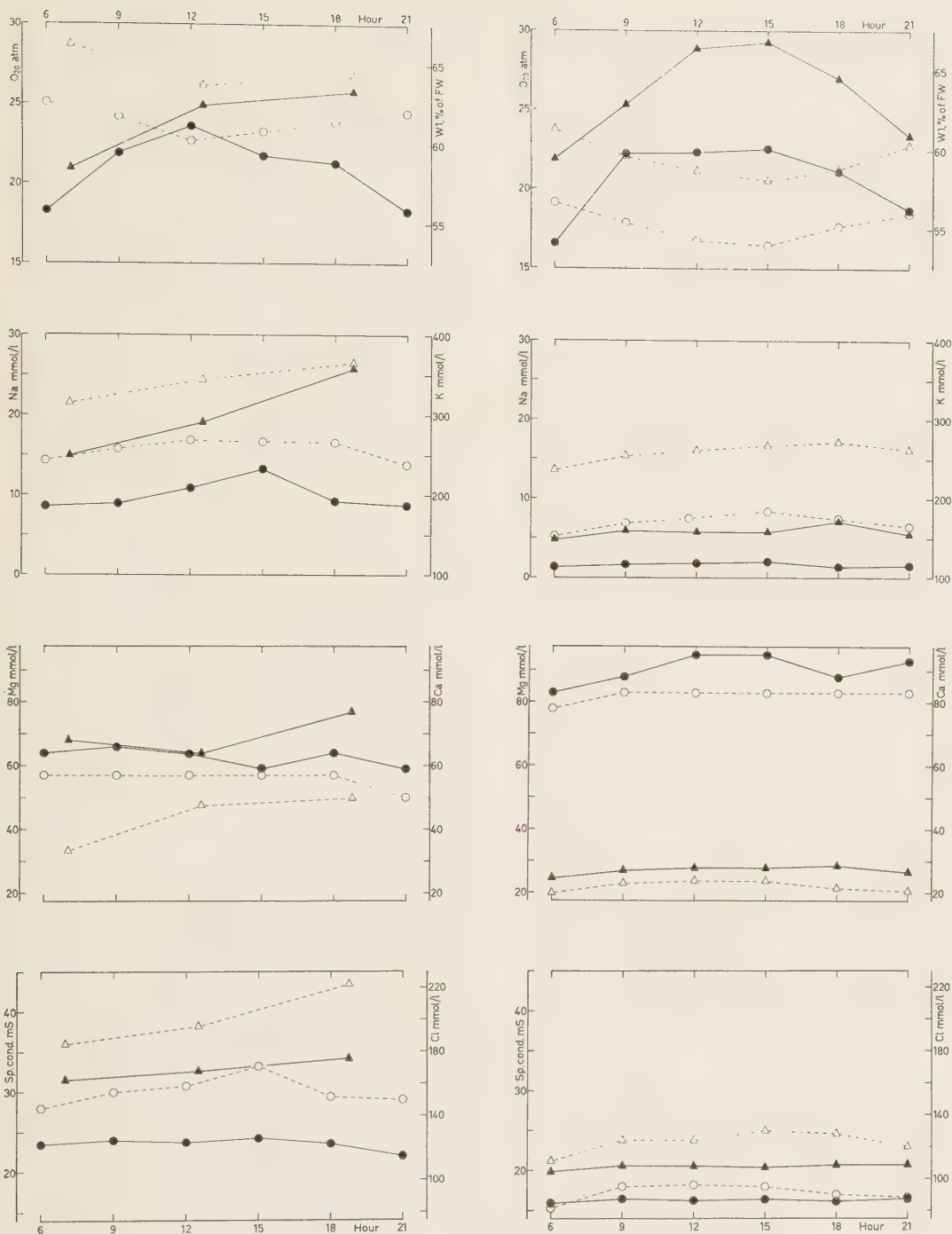


Fig. 140. Daily variation in the expressed sap quality in biotopes 43 Lödösnäs 630723 and 15 Tiken 640815. The left series of diagrams refers to the lower leaves, the right series to the upper leaves. Symbols: Triangle=43 Lödösnäs; circle=15 Tiken. Left axis factors indicated by solid lines and symbols, right axis factors by broken lines and open symbols.

4. Seasonal Variation in Expressed Sap Quality

Also the seasonal variation of the osmotic potential has been investigated in several plants. Compare, for example, STEINER (1933), MÜLLER-STOLL (1938) and KURIMOTO et al. (1954). As for the seasonal variation in the content of different elements in whole plant material see, for example, OLSEN (1948), TAMM (1951), MALMER (1962b), ALLEN & PEAR-SALL (1963) and CAINES (1965).

Besides the diagrams in Fig. 141 showing the seasonal variation in the expressed sap quality in the biotopes 19—20 Vångasjön and 41 Pukavik reference is made to the series of analyses from different parts of the vegetation period from especially biotopes 26—29 Norjesund (Table 34), 43—44 Löddesnäs and 45 A—C Bjärred (Table 55). The difficulties in getting exactly comparable samples of plant material are emphasized. The leaves included in the first samples of the vegetation period are designated "upper leaves". In judging the courses of the curves it should be kept in mind that there is a relatively greater gradual increase in the insertion level (transport distance) for the upper leaves than for the lower ones.

From Fig. 141 it is seen that there was only a slight increase of Na during the vegetation period in the rhizomes in biotopes 19—20 Vångasjön. In 41 Puka-

vik there was a distinct increase (Fig. 141) but in 43 Löddesnäs a decrease (Table 55).

As for the Na content in the leaves, especially the sudden increase just before the end of the vegetation period should be noted. This increase could be very great, as demonstrated by the analyses from the Bjärred biotopes (Table 55). It occurs in connection with the yellowing of the leaves.

The decrease during the vegetation period in the concentration of K in the upper leaves is especially well illustrated from 19—20 Vångasjön, but in 41 Pukavik, the biotope with the highest K content in soil and water, the decrease was comparatively slight. At the same time as there was a K decrease in the leaves the concentration increased in the rhizomes.

The content of Mg increased slightly in the rhizomes. In the leaves there was an increase throughout the vegetation period. ALLEN & PEARSALL (1963) found indications of a Mg concentration decrease in autumn in the uppermost *Phragmites* leaf. OLSEN (1948) found a constant content of Mg in beech leaves from early summer until autumn. For *Narthecium* growing in mires in the Aneboda region MALMER (1962b) demonstrated an increase throughout the vegetation period.

No increase in the Ca content was found in the rhizomes, but in the leaves

Fig. 141. Seasonal variation of total content of elements and the distribution on press-cake and expressed sap. Material of rhizomes, lower and upper leaves from biotopes 19—20 Vångasjön and 41 Pukavik. The contents given in mmol for the quantity of plant material from which one liter of sap is expressable. The lower row includes sap analyses only. Symbols in the diagrams with analyses of Na, K, Mg, Ca and Fe: Thick solid line=sum of expressed sap and press-cake; thin solid line=expressed sap; broken line=press-cake. In the lower row Cl (mmol/l) is indicated by thick solid line, Sp.cond. (mS) by thin solid line and O₂ (atm) by broken line. Δ DM1 and Δ ES indicate the percentage changes in DM1 and ES in relation to the first sample of the year. As for insertion levels and object dimensions see Tables 34 and 55.

there was a continuous rise in the concentration.

An increase in the Fe content of the rhizomes was noticeable only in 20 Vångasjön and in especially the upper leaves it was marked in both 19 and 20.

The course of the concentration conditions of Cl was fairly irregular. It increased in the rhizomes in 19 Vångasjön and 41 Pukavik as well as in the upper leaves in these biotopes. Also in the lower leaves in 19 Vångasjön there was an increase. In the lower Pukavik leaves it decreased and also in 20 Vångasjön there was a decreasing tendency in the upper leaves. In the latter part of the vegetation period the concentration became lower in the rhizomes in the last-mentioned biotope.

The Na invasion in the yellowing leaves in 19 Vångasjön was accompanied by an increase also in Cl. Compare the analyses from Bjärred, where very high Cl concentrations were found (Table 55).

The osmotic potential became gradually higher during the vegetation period in rhizomes as well as in leaves. At the very end of the period there was a drop in the leaves in the Vångasjön biotopes synchronous with the sudden Na increase.

The course of the curves for the specific conductivity is about the same as those for Cl in the rhizomes and the lower leaves. In the upper leaves the conductivity was rather variable.

ALLEN & PEARSALL (1963) found in the uppermost *Phragmites* leaf an indication of a decrease in autumn of N and P as demonstrated for *Betula* leaves by TAMM (1951) and for *Narthecium* leaves by MALMER (1962 b).

5. Variations in Expressed Sap Quality between Clones in Similar and Different Environment

The great variations in expressed sap quality within the plant, the daily and the seasonal variations in the rhizomes and at different levels of the shoot make it difficult to carry out comparisons between clones and biotopes for elucidating the environmentally caused variations. For making reliable comparisons series of analyses from different parts of the vegetation period like those presented in Fig. 141 are necessary. The most comprehensive series of this kind are available from 19—20 Vångasjön and 26—29 Norjesund (Table 34), 41 Pukavik and 43 Lödösnäs (Table 55). Compare also Tables 15, 24 and 44.

The analyses from biotopes 26—29 Norjesund, 33—34 W. Ringsjön and 38—39 Tystrup Sö are used for comparisons between different clones in similar environment. As for Norjesund it should be recalled that differences in the water quality can occur between the biotopes.

Throughout the vegetation period the osmotic potential of the rhizome sap of the hexaploid type A in Norjesund (biotope 26) mostly was higher than that in type B (biotope 27), but the highest Na and Cl concentrations were always found in type B (Table 34). The amounts of Mg and Ca and also, though more variable, K were about the same. There are indications of earlier evacuation of K to the rhizomes in type B, which coincides with the earlier leaf ageing in this type. In the sap from the upper leaves the higher values for osmotic potential were found in type B except at the end of the vegetation period. As in the rhizomes this type also had the highest concentrations of

Na and Cl, but also Mg and mostly Ca in the upper leaves. There was at the end of the vegetation period a sudden increase of Na and Cl in the panicle sap in type B (biotope 27). The higher concentrations in the biotope 27 clone of Na and Cl might possibly be correlated with the slightly higher average salinity in comparison with biotope 26.

In the tetraploid types A and B growing in biotopes 28 and 29, the highest osmotic potential was found in the biotope 29 clone in rhizome as well as in upper leaf sap. On the other hand, this clone, growing nearest to the Baltic, showed the lowest Na and Cl concentrations in the rhizome sap, while in the lower and upper leaves type A mostly had the lowest concentrations. In the sap from all sampled parts of the plants the highest K concentrations were found in type A.

GYÖRFFY (1941) found that in several plant species tetraploid types had slightly lower osmotic potential than diploid ones (determinations of osmotic potential made as in this investigation) when growing under the same environmental conditions. However, the ability of modification in response to changes in the environmental conditions was not the same in both types. According to GYÖRFFY (op. c.) it could be presumed (from laboratory experiments) that the polyploid types have the greatest ability of modification.

Demonstrable differences of this kind could hardly be expected between the polyploid levels in Norjesund by means of analyses with the practised method of sampling in the field. For checking whether there are differences in the osmotic potential between the different types this must, of course, be done on

plants grown from seedlings and which have been cultivated under identical environmental conditions.

In W. Ringsjön (Table 44) the osmotic potential of the sap from rhizomes, lower and upper leaves as well as in shoot tips and panicles was higher in the large-grown clone in biotope 34 than in the small-grown one in biotope 33. The clone with tall shoots had also the highest sap concentrations of K in upper leaves, shoot tips and panicles. However, the highest Cl content in sap from leaves, shoot tips and panicles occurred in the small-grown clone. The age of the lower leaves was not quite equivalent in both clones due to the following circumstance. In the sparse stand of tall shoots (biotope 34) the earliest developed leaves were kept longer than in the dense stand of small shoots (biotope 33). Therefore, an accumulation of Ca has taken place for a longer time in the sampled lower leaves in biotope 34 than in 33. Probably this is — at least in part — the explanation of the great differences in the Ca content of the lower leaves between the clones. In the rhizome sap the Ca content was slightly higher in 33, but in the other sampled shoot parts no regular differences were established.

In Tystrup Sö (Table 44) the leaf sap from the biotope 38 clone with tall shoots had higher osmotic potential than that from the biotope 39 clone. The latter clone had the higher amount of Na but the lower of Cl in rhizomes and leaves. Great differences in the K content were found in the sap of rhizomes and lower leaves, the large-grown clone in biotope 38 had the highest values. As for other analyses there were no or only slight or irregular differences between the clones.

From the comparisons between clones

growing under similar environmental conditions it is seen that in all cases differences in the osmotic potential were found between the clones in question. Also with respect to the concentration of various elements there were interclonal differences. As for Norjesund the influence of environmental conditions (salinity of the surface water) could not be excluded, and in, e.g., W. Ringsjön age differences in the lower leaves were probably an interfering factor through which the possibly prevailing genotypically caused differences in the Ca content of the sap were more or less over-dimensioned. On the whole, the (also genotypically induced) differences in insertion level and growth rapidity ought to be taken into consideration in judging the sap differences between the clones.

In reviewing the factors affecting salt absorption in plants SUTCLIFFE (1962, pp. 70—71), among other things, summarizes as follows: "It is extremely improbable that if any two plants even of the same species were placed under identical conditions, they would each absorb salts in the same proportions or at the same total rate. Individuals of the same clone may be expected to show the smallest differences between one another, while varieties, species and genera show increasing marked contrasts in the pattern of absorption."

Comparisons between different parts of the same clone are made with respect to biotopes 5—6 Helgasjön, 7 A and 7 C Furen and 19—20 Vångasjön. The two biotopes in each group differ from each other with respect to the environmental conditions.

The material from 5—6 Helgasjön is

small and the comparisons are restricted to the upper leaves (Table 15). The difference in the mean insertion level is about 125 cm. While the highest specific conductivity and also the highest content of Na, K and Cl were found in the part of the clone with small shoots in biotope 5, the sap from the tall shoots in biotope 6 had considerably higher osmotic potential (cf. below concerning biotopes 7 A and 7 C Furen).

In Furen the pollution with sewage was restricted to biotope 7 A. However, there was a marked increase in the soil content of K from 7 A to 7 C (Fig. 30). In the expressed sap the highest concentrations of K in lower and upper leaves as well as in panicles were found in 7 C (Table 15). The same distribution was found for Cl but the reverse (in leaves) for Mg and Ca. The amount of Cl in the lower leaves was regionally high in both biotopes. As for the osmotic potential this was found to be slightly higher in the sap of the lower leaves in 7 C. However, with respect to the sap from the upper leaves the difference between the biotopes was greater. In this case the highest values were found in 7 A. The insertion level should in this as well as in other comparisons be taken into consideration. While the mean insertion level was about the same for the lower leaves in both biotopes the upper leaves were situated 30—40 cm higher in biotope 7 A than in 7 C, which might have had some influence on the osmotic potential. In 7 A the lower leaves are more shaded than in 7 C (cf. p. 214). The lowest photosynthetic activity could therefore be expected to be found in the first-mentioned biotope. On the other hand, the environmental conditions may have a more favourable influence and bring about conditions for

a better photosynthetic activity at the level for the upper leaves in 7 A than in 7 C, which also could have contributed to the higher osmotic potential in biotope 7 A (cf. also above concerning biotopes 5—6 Helgasjön).

In Vångasjön the osmotic potential, pH and the Na content of the rhizome sap were always and the specific conductivity mostly somewhat higher in biotope 19 (in the luxuriant part of the stand) than in the closely situated biotope 20 (Table 34, Fig. 141). During the first part of the vegetation period the rhizome sap concentration of K was about the same in both biotopes, but at the end of this time the highest concentration was found in biotope 19. On the other hand, the rhizome sap in biotope 20 had the highest amount of Mg and Fe. Also in the sap from the upper leaves the highest osmotic potential as well as the highest concentration of Na were found in biotope 19. A great increase of Mg and Ca characterized the upper leaves in biotope 19 in the latter part of the vegetation period. In biotope 20 the increase was smaller.

The analyses of sap from different parts within the same *Phragmites* clone indicate that variations in the sap quality can be found. The modificatory differences in growth rate and insertion level ought to be taken into consideration when judging the variations in sap quality. A conception of the uniformity in the sap quality (within the scope of the daily variation) between different samples of homologous parts of the plant is obtained from the series of samples from biotopes 15 Tiken and 43 Lödösnäs accounted for in Fig. 140.

From the fairly comprehensive material of expressed sap analyses in Tables

15, 24, 34, 44 and 55 a conception is obtained of the range in osmotic potential and of the deviations from a theoretic "internal standard composition" with respect to the analysed elements. The material represents a wide spectrum of environmental conditions. From what has been shown above it is evident that the ecologic interpretation in each single case (clone—biotope constellation) ought to be based on an extensive analysis of interfering organism and environmental conditions. In order to avoid repetition of data the concluding comparisons between different clones growing under different environmental conditions are restricted to discussions in connection with Fig. 142 and Tables 61 and 62.

In Fig. 142 the variation in osmotic potential of surface and interstitial water in *Phragmites* biotopes is illustrated. It is seen that the *Phragmites* clones included in this study grow in biotopes in which the osmotic potential of the water (surface and interstitial) varies from about 0 to 12 atm.

While the seasonal variation in the sap from the rhizomes has been shown to be fairly small, that of different shoot parts is much greater. Only the conditions in the rhizomes are taken into consideration here.

In biotope group I (Aneboda) the found variation for Π_{20} of rhizome sap is 9.2—15.3, in group II 8.5—15.5, in group III 8.0—14.9 (northern part) and 7.1—16.0 (Norjesund), in group IV 7.3—14.1 and in group V 9.0—21.9 atm. Among these group IV includes samples from the period June to August only, but the other groups include samples from other seasons too. The mean values for the period when the shoots are full-grown or nearly

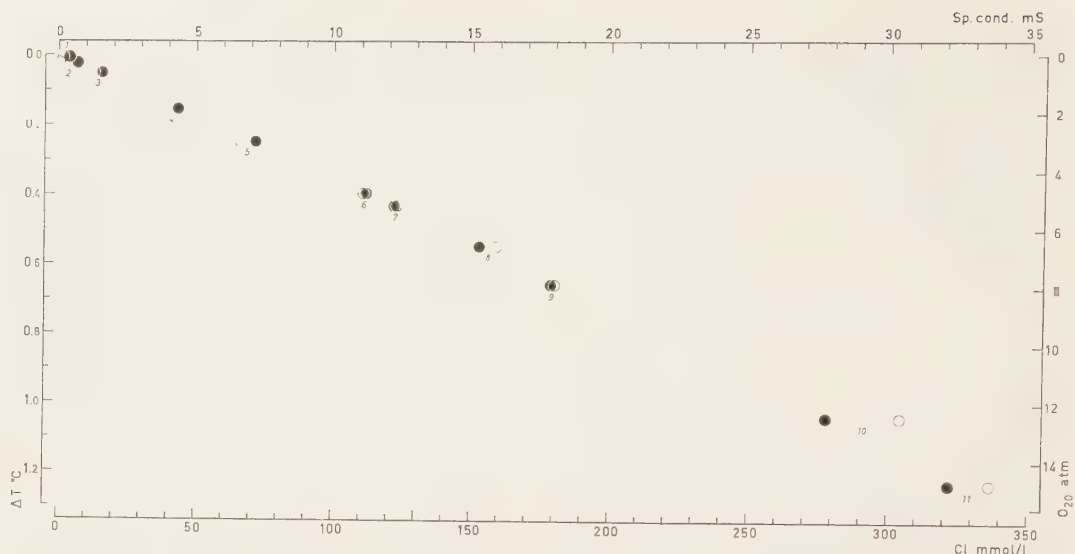


Fig. 142. The correlation between freezing-point depression/osmotic potential and specific conductivity (solid circles)/chloride content (open circles) in surface and interstitial water in the following *Phragmites* biotopes: 1) 15 Tiken 630921, IW, 2) 37 Björkesåkrasjön 640827, IW, 3) 27 Norjesund 630817, SW, 4) 47 Ängen 630820, SW, 5) 43 Lödösnäs 630726, SW, 6) 41 Pukavik 630817, SW, 7) 42 Pukavik 640830, SW, 8) 46 Praestö Fjord 640824, SW, 9) Getterön, polluted coastal biotope south of 47 Ängen 630820, SW, 10) 48 Hakenäs 630821, SW, 11) Lake Techirgiol, Roumania 640710, SW.

full-grown are: I=10.6, II=11.4, III 12.3 (northern part) and 13.0 (Norjesund), IV 11.6 and V 13.7 atm. In the freshwater biotopes, in which the osmotic potential of the water is approximately 0 atm, most of the clones had a value for O_{20} between 9 and 12 atm (shoots full-grown or nearly full-grown). In Norjesund and in the coastal biotopes most of the values were higher. The highest found value, viz., 21.9 atm, was obtained in 48 Hakenäs, the biotope with the highest salinity of the surface water. From the basic level of about 11 atm in the rhizome sap found in biotopes with a water O_{20} value approximately=0 atm the rise in the sap potential to ca. 22 atm seems to be a direct result of the increase in the water potential with about 12 atm. The rise from ca. 11 atm in the Aneboda, Veden—Tiken—Ängsjön and eutrophic biotopes to ca. 13.7 atm in the coastal biotopes is in Fig. 142 corresponded to a

rise in the specific conductivity from <0.55 mS in the freshwater biotopes to a specific conductivity of about 7—8 mS in the coastal biotopes. In reality the average conductivity in the coastal biotopes is about the same. The values from the northern part of the Orlunden—Norjesund region deviate fairly greatly from the scheme of correlations between the conditions in the plant and the environment. This is an indication that the comparisons should be made with care and that a series of interfering conditions must be taken into consideration. Among these are the differences in growth rate (age) of the rhizomes, the developmental degree of the shoots, the soil stratigraphy as well as the irregularity with time of the salinity in the biotopes.

The great variations in the relation between the concentrations in water and soil and the concentration in the ex-

pressed sap are easily seen from the examples given in Table 61, which are briefly commented here. It is emphasized that the figures for the amounts of elements in interstitial water and soil from which part of the concentration factors are calculated refer to the superficial soil layer with the highest frequency of fine roots. As presumed above (p. 199) a considerable part of the yearly uptake of elements obviously takes place from this layer which during the growth period becomes interwoven with fine roots especially from the vertical rhizomes. The samplings of superficial water, interstitial water and soil were not always carried out at the same time.

There is a distinct difference in the concentration factors between the freshwater and the coastal biotopes with respect to Na, K and Cl. In relation to the environmental conditions the concentration in the sap from the coastal biotopes is considerably lower than in the freshwater biotopes. As for Mg the ES/SW and ES/IW quotients were also much higher for the freshwater biotopes, while the ES/HAc quotients could be the same in both categories of biotopes. Also for Ca ES/HAc quotients of about the same size could be found in freshwater and coastal biotopes. However, the ES/SW and ES/IW quotients were lower for the coastal than for most of the freshwater biotopes. The intraplantal concentration differences are reflected especially well in the quotients for Mg and Ca.

Within the group of freshwater biotopes there are with respect to the ES/SW and ES/IW quotients for Ca fairly marked differences between the Scanian

biotopes and the biotopes from the more or less oligotrophic regions.

The figures in Table 62 give an idea of the relative stability in the concentration in the expressed sap of different elements in various environments (compare also Figs. 139—141). The composition of the sap from the rhizomes and leaves of the grown-out panicle shoots in biotope 19 Vångasjön is given as a theoretical "internal standard composition" for each sampled level. Also the water and soil analyses from this biotope are given as references.

It is seen that between the freshwater and coastal biotopes the differences in the internal concentration are fairly small for K and Mg as well as for Ca and Cl. The greatest difference is found for Na. However, with respect to the great concentration differences in water and soil also this is fairly small. It is a noticeable fact that in the coastal biotopes the concentration of Cl in the leaves is mostly not higher than in the main part of the freshwater biotopes. On the whole, the leaves in 19 Vångasjön had a relatively high Cl content.

Within the group of freshwater biotopes in Table 62 there are in the lower leaves distinctly higher amounts of Ca in the Scanian than in the other biotopes. In the biotopes with highest content of Ca, viz., 36 Krankesjön and 37 Björkesåkrasjön, noticeably high amounts of Na were found in the leaves. Biotope 37 Björkesåkrasjön was characterized by very low Cl content in the interstitial water. The leaves here were also among those with the lowest relative concentration of Cl. Compare, however, also the low content of Cl in the leaves in 41 Pukavik.

Table 61. The relation between the concentration of Na, K, Mg, Ca and Cl in sap expressed from rhizomes (Rz), lower leaves (Ll) and upper leaves (Ul) and the concentration of these elements in surface water (SW), interstitial water (IW) and soil (HAc-extract). The concentration factors calculated on the basis of the amounts of the elements per liter expressed sap, water and whole soil. Sap from grown out shoots with panicles. Samples of interstitial water and soil from the layer with highest frequency of fine roots.

Biotope	Na									K									Mg								
	SW			IW			HAc			SW			IW			HAc			SW			IW			HAc		
	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul
15 Tiken		34	5.2		11	1.7		15	2.2		3700	2500		14000	9700		330	230		350	560		40	64		17	27
16 Ångsjön	27	8.0	9.5	23	6.7	7.9	10	3.0	3.6	7000	8900	8700	3300	4100	4100	240	310	300	170	1600	1600		390	400		1.8	17
19 Vångasjön	64	21	6.7	40	13	4.2	16	5.5	1.7	4900	7900	6600	2700	4300	3600	550	880	740	78	930	950		33	390		1.4	16
20 Vångasjön	50		6.1	27		3.3	16		1.9	4900		8500	2800		4800	430		740	93		400			400		1.9	8.4
22 Örlunden	26	6.4	5.6	13	3.2	2.8	7.9	1.9	1.7	3100	4600	5600	1300	1900	2300	120	170	210	92	770	400		23	190		0.9	7.2
33 W. Ringsjön	47	7.8	3.3	35	5.7	2.4	20	3.3	1.4	4100	8700	9600	2800	5900	6500	190	410	430	58	630	330		47	520		2.3	13
34 W. Ringsjön	43	15	5.1	27	9.0	3.2	16	5.6	2.0	1900	3500	4500	6100	11000	14000	380	690	880	36	870	250		20	480		0.7	17
36 Krankesjön	16	44	25	11	30	17	6.9	18	10	1200	2200	1500	2600	4900	3400	110	200	140	16	330	140		4.5	93		40	2
37 Björkesåkrasjön		51	18		62	22		54	19		1800	1800		6600	6500		160	160		2400	1400		990	580		23	14
41 Pukavik	1.2	0.7	0.1					1.0	0.6	0.1	61	72	67													0.2	3.7
43 Löddesnäs	3.0	0.9	0.2	1.3	0.4	0.1	1.0	0.3	0.1	170	340	250	75	160	110	33	69	50	1.8	21	21		0.8	9.7		9.0	3.0
48 Hakenäs	0.6	0.4	0.1					1.3	0.9	0.2	19	31	29													0.5	4.1

Biotope	Ca									Cl								
	SW			IW			HAc			SW			IW			HAc		
	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul	Rz	Ll	Ul
15 Tiken		190	280		22	33		9.2	13		300	170		260	14			
16 Ångsjön	21	420	390	11	220	200	0.3	6.3	5.7	520	630	540	400	490	420			
19 Vångasjön	14	260	260	12	220	230	0.4	7.8	8.0	260	690	480	160	430	300			
20 Vångasjön	16		100	18		110		0.5		3.0	280		410	190	270			
22 Örlunden	10	290	130	7.3	210	92	0.2	6.4	2.8	320	610	520	490	940	800			
33 W. Ringsjön	5.4	100	37	4.6	87	32	0.4	6.7	2.5	150	470	380	200	610	500			
34 W. Ringsjön	4.6	190	35	2.6	110	20	0.3	5.0	2.2	140	370	270	360	920	670			
36 Krankesjön	1.1	110	31	0.3	25	7.1	0.01	0.7	0.2	110	360	230	82	270	170			
37 Björkesåkrasjön		280	190		61	41		6.9	4.6		220	150		4100	2700			
41 Pukavik	1.2	26	21					0.2	4.0	3.2	1.4	1.2	0.8					
43 Löddesnäs	1.7	27	31	1.2	19	22	0.2	3.0	3.4	4.2	5.0	3.6	1.8	2.2	1.6			
48 Hakenäs	1.0	11	15					0.1	0.7	0.9	0.7	0.9	0.4					

Table 62. The relation between some biotopes with respect to the concentration of different elements in surface water (SW), interstitial water (IW) and whole soil (HAc-extract) as well as in sap (ES) expressed from rhizomes (Rz), lower leaves (Ll) and upper leaves (Ul). The concentrations in 19 Vångasjön are given the value 1.0 and the concentrations found in the other biotopes put in relation to this. Sap from grown out shoots with panicles. Samples of interstitial water and soil from the layer with highest frequency of fine roots.

Biotope	Na					K					Mg					Ca					Cl														
	SW	IW	HAc	ESRz	ESLl	ESUl	SW	IW	HAc	ESRz	ESLl	ESUl	SW	IW	HAc	ESRz	ESLl	ESUl	SW	IW	ESRz	ESLl	ESUl												
15 Tiken	1.4	2.7	0.9	2.2	1.1	1.2	2.6	0.4	3.2	1.2	1.1	0.8	2.1	7.8	0.8	0.8	1.3	1.2	8.8	0.8	0.9	1.3	1.5	1.2	8.8	0.8	0.9	1.3	1.5	1.2	8.8	0.8	0.9	1.3	
16 Ångsjön	0.7	0.5	0.5	0.3	1.0	0.8	0.8	0.9	2.4	1.1	0.8	1.0	0.5	0.8	0.8	1.1	0.8	0.8	0.5	0.9	1.1	0.8	0.9	0.8	0.5	0.9	1.1	0.8	0.9	0.8	0.5	0.4	1.1	0.5	0.6
19 Vångasjön	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	
20 Vångasjön	1.0	1.1	0.8	0.8	0.9	1.0	1.0	1.0	1.3	1.0	1.3	1.0	1.0	0.4	0.8	1.2	0.4	1.0	0.8	1.0	1.1	0.4	1.0	0.9	1.1	0.9	1.1	0.9	1.1	0.9	1.1	0.9	1.1	0.8	
22 Örlunden	0.9	1.1	0.8	0.4	0.3	0.7	1.5	2.0	4.5	0.9	0.9	1.3	0.8	1.3	1.4	0.9	0.6	0.3	0.8	0.9	1.0	0.5	0.9	0.4	0.8	0.9	1.0	0.5	0.9	0.4	0.8	0.3	1.0	0.7	0.9
33 W. Ringsjön	1.3	1.1	0.8	0.9	0.5	0.6	0.7	0.5	1.6	0.6	0.8	1.0	1.1	0.6	0.5	0.8	0.8	0.4	4.1	4.1	1.9	1.5	1.6	0.6	1.0	0.5	0.6	0.7	0.8	0.7	0.8	0.7	0.8	0.7	0.8
34 W. Ringsjön	1.3	1.3	0.9	0.9	0.9	1.0	1.7	0.3	1.0	0.7	0.8	1.1	1.3	0.9	1.1	0.6	1.2	0.3	4.2	6.3	2.0	1.3	3.1	0.5	1.1	0.3	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	
36 Krankesjön	2.0	1.8	1.2	0.5	4.2	7.4	3.1	0.7	3.6	0.7	0.8	0.7	3.0	4.4	4.0	0.6	1.1	0.4	6.8	26	35	0.5	3.0	0.8	1.8	1.5	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	
37 Björkesåkrasjön	2.0	1.0	0.5	4.7	5.3	2.3	2.3	0.4	3.0	0.5	0.6	0.6	0.6	0.6	1.1	1.6	0.9	1.6	3.6	14	4.5	4.0	2.6	1.5	0.05	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
41 Pukavik	340	97	6.1	11	6.3	90	33	1.1	0.8	0.9	140	6.7	1.2	1.5	0.9	9.6	1.9	0.8	1.0	0.8	300	1.7	0.5	0.5	1.7	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
43 Löddesnäs	110	150	78	4.9	4.5	3.2	29	35	16	1.0	1.3	1.1	45	41	5.6	1.0	1.0	1.0	8.4	10	2.4	1.0	0.9	1.0	89	130	1.4	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
48 Hakenäs	930	110	8.9	17	13	230	28	0.9	0.9	1.0	390	4.1	1.5	1.0	1.5	20	9.5	1.4	0.9	1.1	830	2.3	1.1	0.7	2.3	1.1	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7

II. Dynamic Aspects on the Development of *Phragmites* Reed-Beds

In South Sweden most of the lakes are shallow. To a large extent the water level in these has been lowered. This has favoured — sometimes in combination with pollution — the quantitative development of the macrophytes, in many cases especially the graminids. See LILLIEROTH 1950. According to the terminology used by, e.g., LINKOLA (1916) *Phragmites communis* should be included among the apophytic species in the group of hemerophilous organisms (as for the terminology see also BJÖRK 1962 b).

The increase in the standing crop of *Phragmites* accompanying a lowering of the water level is demonstrated in this paper especially from the Aneboda and Veden—Tiken—Ängsjön regions. Among the Scanian lakes Krankesjön and Björkesåkrasjön offer good examples for studies on the dynamics in the reed-bed development after lowering.

The first phase in the reed-bed development in a lowered lake includes the colonization of the shallow zone along the shore either from earlier occurring stands or from seedlings.

In several lowered lakes the sediment reaches the water line at summer normal water level. In the eulittoral zone the

ground is kept moist during the summer due to subsoil water supply in the zone above the sediment limit. Judging from observations in south Swedish lakes there seem to be favourable environmental conditions for germination of *Phragmites* seeds in this zone. As far as we know the development of *Phragmites* seedlings cannot take place under water as is the case of, for example, *Scirpus lacustris* (compare SEIDEL 1955). Therefore isolated *Phragmites* stands growing in deeper water are probably always spread by vegetative propagation from stands developed in the littoral zone. The rapid quantitative increase of *Phragmites* in moderately lowered shallow lakes in the main seems to take place due to spreading from already established stands.

The outer depth limit attainable by the rooted *Phragmites* reed-bed is, among other things, dependent on the character of the bottom. In lakes with loose gyttja the initial rapid lakeward expansion is often interrupted by plaur formation. This usually takes place before the maximal depth for the rooted *Phragmites* is reached.

The formation of a plaur girdle imme-

diately outside the rooted *Phragmites* reed-beds in a lake implies a more or less temporary retardation in the overgrowth of hyperhydrites. According to my observations in Swedish lakes the standing crop in the case of *Phragmites* decreases in connection with plaur formation compared with the conditions in the rooted stand.

The outlined dynamics in reed-bed development are, of course, within the investigation area not restricted to *Phragmites* but are valid also for, e.g., *Equisetum fluviale* and *Typha angustifolia*.

In its present stage Lake Björkesåkra-sjön is an illustrative example of a lowered shallow lake which has reached the plaur-girdle phase in the reed-bed development. During most years of this investigation there was in the open lake a very rich development of elodeids, but no or only weak turbidity from plankton.

In Lake Krankesjön plaur formation

in the main takes place at high water level. During the vegetation period the water depth in most of the areas hitherto colonized by *Phragmites* is too low for floating plaur. A moderate raising of the water level would result in a vigorous formation of plaurs. In the case of Krankesjön there has earlier been a rich development of charophytes (cf. p. 144). During the years of this investigation there was in the summer always a strong plankton turbidity. In comparison with the earlier conditions the quantitative development of elodeids had probably decreased. (As for the interrelation between the production of hyphydrites and plankton cf. MATHIESEN 1966.)

Due to "calving" and erosion gaps can be formed in the plaur girdle in a lake. Through these an expansion lakewards takes place from the rooted stands inside the girdle. This expansion is again interrupted by plaur formation.

III. Aspects on the Rôle of Macrophytes in the Limnic Ecosystem

The investigations of the composition of expressed sap from leaves and rhizomes as well as other analyses of *Phragmites* shoot parts indicate that some of the essential elements absorbed from the environment at least in part are returned to the rhizomes at the end of the vegetation period.

In contrast to these elements which are more or less preserved within the plant, other elements are not transported to the rhizomes in autumn. This means that there is with respect to this group of elements a transport from the bottom via the plant to the water and superficial sediment layer in a lake. The transports within and via the plant are schematically illustrated for a *Phragmites* stand in Fig. 143.

Several ecologically important sections of the roughly outlined scheme are incompletely known. This includes, for example, the course at the very end of the vegetation period, i.e., at the time of the sudden increase of Na in the leaves. Compare Fig. 141 as well as ALLEN & PEARSALL 1963, p. 183. Furthermore, the extent and ecologic importance of the leaching from growing and dead

plant material still seem to be largely unknown.

The fact that essential nutrients can be preserved and repeatedly utilized in the development of shoots in a perennial plant like *Phragmites communis* has important ecologic consequences. The immediate reflexion made on the basis of this knowledge is that it can be difficult to establish a direct correlation between the actual environmental conditions in the soil within the rhizosphere as well as in the water and the quantitative development of the perennial plant.

Thus an occasional addition of nutrients (e.g., a short-time outlet of sewage) to the superficial soil layer can have a prolonged effect on the productivity. This has been tested in manurial field experiments (BJÖRK in prep.). In the same way the supply of nutrients preserved within the perennial plant system can be enriched for a long time from the soil within the rhizosphere. At the same time the soil can have been more or less impoverished. (Cf. the relation between a quantitatively rich development of phytoplankton in summer and the water deprived of essential nutrients.) How-

ever, the deeply rooted macrophytes in the littoral zone frequently seem to be furnished with nutrients by the subsoil water from which an enrichment can take place. On the basis of this the discrepancies between the fairly rich development in poor coarse-grained minerogenic soils can be explained.

Through the selected transports of elements occurring in the *Phragmites* reed-beds the soils within the rhizosphere are included in the limnic ecosystem. The interaction of this biotic factor is, of course, dependent on the proportions between the water body and the quantitative development of the reed-beds. The current development including overgrowth of hyperhydrites in shallow south Swedish lakes demands a penetration of this problem (compare also WETZEL 1964).

The uneven distribution of elements within the shoots as well as the seasonal variations make it rather difficult to calculate the content in the standing crop. On the basis of calculations from mean values for upper and lower leaves of shoots with panicles and the average

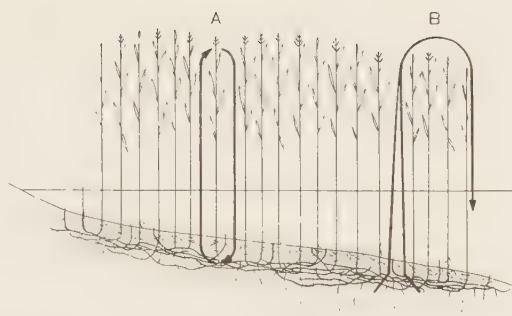


Fig. 143. Schematic illustration of the rôle of *Phragmites* and other rooted perennial aquatic macrophytes in the transportation of elements within the limnic ecosystem. The arrow A indicates the uptake from the bottom of elements which are transported to the shoots but evacuated to the rhizomes at the end of the vegetation period. The arrow B indicates the uptake from the bottom of 1) elements which remain in the shoots at the end of the vegetation period and are eventually transferred to the sediment with the detritus and 2) elements which are leached from the shoots and thus transferred to the water during or after the vegetation period.

distribution between press-cake and expressable sap at about the time of flowering the amounts included in the leaves of the standing crop are given for some biotopes in Table 63.

Table 63. The distribution of elements on expressable sap and press-cake and the total amount of elements in leaves of standing crop, given in mmol/m²
The figures for Cl calculated on the basis of the mean values for Na and K. PC=press-cake, ES=expressable sap. T=total.

Biotope	Year	Standing crop, leaves %		Percentage of leaves in standing crop		Na			K			Mg			Ca			Fe			Cl		
		Standing crop, leaves %	Percentage of leaves in standing crop	PC	ES	T	PC	ES	T	PC	ES	T	PC	ES	T	PC	ES	T	PC	ES	T		
7 A Furen	1964	160	30	0.42	0.85	1.3	17	47	64	6.0	10	16	12	16	28	0.38	0.02	0.40	16	37	53		
7 C Furen	1964	38	14	0.07	0.15	0.22	4.6	12	17	1.0	1.7	2.7	1.5	2.0	3.5	0.09	0.004	0.10	4.2	9.9	14		
8 Salen	1964	342	19	0.42	0.84	1.3	35	95	130	17	28	45	16	21	36	1.1	0.05	1.2	33	78	111		
10 Rolsmosjön	1963	9	14	0.02	0.04	0.06	1.1	2.9	4.0	0.24	0.41	0.65	0.22	0.30	0.52	0.029	0.001	0.03	0.73	1.7	2.4		
11 Rolsmosjön	1963	198	16	0.21	0.43	0.65	27	74	101	10	17	27	5.5	7.3	13	0.48	0.02	0.50	13	29	42		
13 Veden	1963	308	21	0.39	0.79	1.2	36	97	133	13	22	35	17	22	39	0.62	0.03	0.65	35	82	118		
15 Tiken	1964	109	21	0.36	0.73	1.1	9.5	26	35	5.4	9.2	15	6.0	7.9	14	0.31	0.01	0.33	6.5	15	22		
16 Ängsjön	1964	8	16	0.008	0.016	0.024	0.62	1.68	2.3	0.34	0.57	0.91	0.36	0.48	0.85	0.029	0.001	0.03	0.43	1.0	1.4		
17 Ängsjön	1964	62	13	0.07	0.13	0.20	5.4	15	20	3.1	5.3	8.5	4.6	6.1	11	0.22	0.009	0.23	4.2	9.9	14		
19 Vängsjön	1963	202	19	0.55	1.12	1.7	21	57	78	12	21	33	14	18	32	0.50	0.02	0.53	26	60	85		
33 W. Ringsjön	1963	283	17	0.39	0.79	1.2	25	69	94	10	17	27	21	28	49	0.19	0.01	0.20	27	63	89		
34 W. Ringsjön	1963	353	16	0.62	1.26	1.9	33	90	123	16	27	42	42	56	98	0.41	0.02	0.43	27	62	89		
35 Krankesjön	1964	79	16	0.49	0.99	1.5	5.8	16	21	2.9	4.9	7.7	7.7	10	18	0.22	0.01	0.23	7.3	17	24		
36 Krankesjön	1964	482	20	4.8	9.8	15	30	81	111	17	29	45	47	62	109	0.84	0.04	0.88	42	99	141		
37 Björkesåkrasjön	1964	254	21	2.3	4.7	7.0	11	29	40	14	23	37	40	52	92	0.48	0.02	0.50	11	25	36		
38 Tystrup Sö	1963	413	19	0.89	1.8	2.7	40	109	149	18	31	49	48	63	111	0.67	0.03	0.70	46	107	152		
39 Tystrup Sö	1963	275	19	0.84	1.7	2.5	23	63	87	10	18	28	27	35	62	0.46	0.02	0.48	25	59	85		
41 Pukavik	1963	239	14	5.6	11	17	19	51	70	15	26	41	12	16	29	0.55	0.02	0.58	14	34	48		

Retrospects and Prospects

As mentioned in the introduction these investigations were started with the intention of including a series of limnic macrophyte species, comprising in addition to *Phragmites communis* also *Equisetum fluviale*, *Typha latifolia* and water lilies. However, it proved necessary to limit the object for investigation to *Phragmites communis*, one of the most common aquatic macrophytes within the investigation area.

The paper presented here is intended to constitute the first one in a series of studies concerning the rôle of the macrophytes in the limnic ecosystem. The main stress has been laid upon the attempt to demonstrate the very wide variation in the environmental conditions between different biotopes as well as the very wide variation within the organism *Phragmites communis*. The number of constellations with regard to environmental conditions and *Phragmites* types is tremendously great in nature. The ecology is therefore very complicated, a contributory and stimulating cause of the lively and large-scale *Phragmites* research developed in several countries. However, among the limnic organisms *Phragmites communis*, of course, does not at all constitute a unique example of

variability. As is well known, limnic biotopes and ecosystems are often more or less isolated from each other and special types within the organism species can be developed. While it is comparatively simple to characterize the environmental conditions, the definition of the organism material is associated with great difficulties. In limnologic investigations hundreds of organisms, mostly characterized by names only, are often treated in one and the same study. Only a rather superficial knowledge about the ecology of the particular organism species is obtainable in this way.

For autecologic investigations a clone-forming species like *Phragmites communis* constitutes an excellent object. In the clones it is possible to get plenty of material from shoots which are genotypically identical. A clone may extend over an area within which there are variations in the environmental conditions and clones of different genetic constitution may also grow side by side under similar environmental conditions. In this investigation utilization of both of these possibilities of comparison has been attempted.

The working plan for the limnologic investigations of macrophytes is as follows:

1. The present paper includes the reconnoitring field ecologic studies carried out in order to get as broad a basis as possible concerning the knowledge of the variation in environment and organism with respect to *Phragmites communis* within the area of investigation and at the same time an idea of the ecologic characteristics.
2. On the basis of these findings special sections are studied in order to elucidate the variability, norms of reaction and rôle in the limnic ecosystem of *Phragmites communis*. Some of the investigations enumerated below have already been totally or partly carried out and papers are in preparation.
 - a. Field experiments carried out in order to study in detail the reaction against an auxotrophication by sewage. (Paper in preparation.)
 - b. Reconnoitring field experiments involving the cultivation of different *Phragmites* types under similar environmental conditions. (Paper in preparation.)
 - c. Investigations of *Phragmites communis* within other geographical regions with other environmental conditions and *Phragmites* types. (Cf. BJÖRK 1966. Paper about further investigations in Iraq in preparation.)
 - d. Investigations of the P and N balance in pure and homogeneous reed-beds growing in biotopes with different kinds of homogeneous bottom substratum and with different amounts of subsoil water supply.
 - e. Investigations of the leaching processes during the vegetation period from growing and cut-off shoots. This study constitutes also (like d) a detail study in the great complex concerning that part of the balance and circulation in the limnic ecosystem of plant nutrients which is affected by the activity of the macrophytes. (The work is part of an ecologic group investigation of lake restoration carried out in cooperation between ecologic institutes of Lund University.)

Abstract

The main aim of the investigation has been to study (1) the variation in the environmental conditions between different *Phragmites communis* biotopes, (2) the variation and the variability within the organism and, on the basis of these observations (3) the connection between the environment and the organism, i.e., the ecology of *Phragmites communis*. In this paper the results are presented in (I) the Analytic-Descriptive Part and (II) the Synthetic Part.

In the Analytic-Descriptive Part analyses of environmental conditions and organism material from five groups of biotopes are included (pp. 28—29). The first two of these represent oligotrophic regions in South Sweden. The development of *Phragmites* in intact as well as in auxotrophicated (due to water level lowering and to discharge of sewage and industrial waste-water) biotopes is described. The third group includes biotopes in one and the same small water-course system, the fourth biotopes in eutrophic regions and the fifth coastal biotopes. For practical purposes the biotopes are numbered (1—48 together with some additional biotopes, 1 A, 1 B etc.).

The organism analysis (methods on p.

11 ff.) comprise determinations of polyploid level, estimation of pollen quality, biometric analyses including pollen, stomata and different shoot qualities as well as determination of standing crop and leaf area. The distribution of rhizomes and roots within the rhizosphere, panicle frequency and flowering time were registered. Furthermore, physical and chemical analyses were carried out on expressed sap and press-cakes.

The environmental analysis (methods on p. 22 ff.) from most of the biotopes comprise soil and water.

Summaries are given of the analyses for each of the biotope groups (pp. 61, 89, 124, 154 and 183 ff.).

In the Synthetic Part the observations on the variation and variability of different qualities in *Phragmites communis* are summarized and put in relation to the environmental conditions.

The investigated *Phragmites* material includes clones at the tetraploid and hexaploid level. The latter is represented only in biotopes 26—27 Norjesund (and the additional biotopes 26 A and 27 A—C) and in 30 Jägern.

The ecologic studies are based (1) on the regional investigations, (2) on obser-

uations made on different clones in similar environment and (3) on observations in differing biotopes in which one and the same clone is represented.

It is shown that the variation within the species is very great (Figs. 37, 59, 86, 108 and 133). The dissimilarity in the development of genotypically different clones as well as the ability of modification within the clones are demonstrated. The increase in the quantitative development in response to auxotrophication is exemplified. There is a preser-

vation of essential nutrients within the perennial plant system and due to this also a short-time increase in the nutrient supply can have a prolonged effect, i.e., there can be a continued increased production of organic matter in the *Phragmites* stand.

From the available material of observations the dynamic course in the development of reed-beds in shallow lakes is described, and aspects on the rôle of the perennial macrophytes in the limnic ecosystem are presented.

Literature Cited

Abbreviations according to "World List of Scientific Periodicals" 4th ed., 1963—1965

- ÅBERG, B. & RODHE, W. 1942. Über die Milieufaktoren in einigen südschwedischen Seen. — *Symb. bot. upsal.* 5: 3.
- ADRIANI, M. J. 1945. Sur la phytosociologie, la synécologie et le bilan d'eau de halophytes de la région néerlandaise méridionale, ainsi que de la méditerranée française. — *Communs Stn int. Géobot. médit. alp.* 88.
- AHL, T. 1962. Om sulfittfabrikens inverkan på recipientens jonsammansättning och ekologi. — *Vattenhygien* 18.
- ALLEN, S. E. & PEARSALL, W. H. 1963. Leaf analysis and shoot production in *Phragmites*. — *Oikos* 14.
- ALMBORN, O. 1948. Distribution and ecology of some South Scandinavian lichens. — *Bot. Notiser. Suppl.* 1: 2.
- ALMESTRAND, A. 1951. Studies on the vegetation and hydrochemistry of Scanian lakes. II. Ion determinations in lake waters. — *Bot. Notiser. Suppl.* 2: 3.
- 1965. Utredning rörande följderna av överpumpning av vatten från Lagan till Ringsjön och Vombsjön från limnologisk synpunkt. — *Statens offentliga utredningar* 1965: 8. Stockholm.
- ALSTERBERG, G. 1926. Die Winklersche Bestimmungsmethode für in Wasser gelösten elementaren Sauerstoff sowie ihre Anwendung bei Anwesenheit oxydierbarer Substanzen. — *Biochem. Z.* 170.
- 1927. Die Sauerstoffschichtung der Seen. — *Bot. Notiser* 80.
- ANDERSEN, S. A. 1924. Kvartærgeologiske iagttagelser i egnen syd for Sorø. — *Meddr dansk geol. Foren.* 6.
- 1931. Om aase og terrasser inden for Susaa's vandomraade og deres vidnesbyrd om isafsmeltningens forløb. — København.
- ANDERSEN, S. T. 1960. Silicone oil as a mounting medium for pollen grains. — *Danm. geol. Unders.* 4: 4.
- ANDERSSON, A. 1948. Näringstillgång och planktonutveckling i några skånska sjöar. — *Vattenhygien* 4.
- ANDERSSON, E. 1954. Några data om pollenvariationen och pollenfertiliteten hos gran och tall. — *Svensk Papp-Tidn.*
- ÅNGSTRÖM, A. 1958. Sveriges klimat. — Stockholm.
- ANTIPA, G. 1910. Die Biologie des Inundationsgebietes der unteren Donau und des Donaudeltas. — *Proc. Int. Congr. Zool.* 8.
- ATLAS ÖVER SVERIGE. 1953—. — Stockholm.
- AVDULOW, N. P. 1931. Karyo-systematische Untersuchung der Familie Gramineen. — *Trudy prikl. Bot. Genet. Selekt. Suppl.* 43.
- BAGGESGAARD RASMUSSEN, H., BJERRESØ, G., BÖCHER, T. W. & ILVER, K. 1948. Rørsumpvegetationen i Danmark. Dens sammensætning, forekommende stoffer og mulighederne for disses udnyttelse med særlig henblik paa produktionen af cellulose. (With English summary.) — *Ingvidensk. Skr.* 1948: 1.
- BEHRENS, S. 1960. The main features of the bedrock morphology in South and Central Sweden. — *Svensk geogr. Årsb.* 36.
- BERG, K. 1943. Physiographical studies on the river Susaa. — *Folia limnol. scand.* 1.
- BERGLUND, B. E. 1963 a. Vegetation på ön Senoren III. Havsstrandvegetationen. (With English summary.) — *Bot. Notiser.* 116.

- 1963 b. Late-Quaternary records of *Sanguisorba officinalis* in south-eastern Sweden. — Bot. Notiser 116.
- 1966. Late-Quaternary vegetation in eastern Blekinge, southeastern Sweden. A pollen-analytical study. I. Late-Glacial time. — Op. bot. Soc. bot. Lund 12: 1.
- BERGLUND, B. E., CURRY-LINDAHL, K., LUTHER, H., OLSSON, V., RODHE, W. & SELLERBERG, G. 1963. Ecological studies on the mute swan (*Cygnus olor*) in southeastern Sweden. — Acta vertebr. 2: 2.
- BERGSTEN, F. 1931. The annual fluctuation of the sea-water stage on the coasts of Scandinavia and Denmark. — Geogr. Annlr 13.
- BERNSTEIN, L. 1961. Osmotic adjustment of plants to saline media. I. Steady state. — Am. J. Bot. 48.
- 1963. Osmotic adjustment of plants to saline media. II. Dynamic phase. — Am. J. Bot. 50.
- BĒRZIŅŠ, B. 1951. On the Collothecacean Rotatoria. With special reference to the species found in the Aneboda district, Sweden. — Ark. Zool. 2. 1: 37.
- BIEBL, R. 1958. Der Einfluss der Mineralstoffe auf die Transpiration. — Handb. PflPhysiol. 4.
- BJÖRK, S. 1956. Vattenvård och vattenproblem vid Västra Örlundsån. (With German summary.) — Skr. söd. Sver. FiskFör.
- 1957. Listerlandet och Ryssberget. — Natur i Blekinge. Uppsala.
- 1960. Tabellaria Teilingii i planktonsamhällen från sydsvenska sjöar. (With English summary.) — Skr. söd. Sver. FiskFör.
- 1962 a. Limnologiska undersökningar i Algutsboda-området. Samband mellan organismvärld och miljöförhållanden i sjöar, åar och bäckar. — Algutsbodaboken. Nybro.
- 1962 b. Investigations on Margaritifera margaritifera and Unio crassus. Limnologic studies in rivers in South Sweden. — Acta limnol. 4.
- 1963. Kromosomgeografi och kromosomekologi beträffande Phragmites communis. Några resultat av regional-limnologiska undersökningar. (Chromosome geography and ecology of Phragmites communis. Some results of regio-limnologic studies.) — Skr. söd. Sver. FiskFör.
- 1965. Föränderliga vatten. — Skånes Nat. 52.
- 1966. Report on ecologic investigations of Phragmites communis within the region around the lower parts of the Euphrates and Tigris. Survey based on material collected during the period December 1965 to May 1966. — Mimeographed. Institute of Limnology, Lund.
- BJÖRK, S. & DIGERFELDT, G. 1965. Notes on the limnology and post-glacial development of Lake Trummen. — Bot. Notiser 118.
- BJÖRKQVIST, I. 1961. Kromosomtalsförhållanden inom släktet Alisma L. (With English summary.) — Bot. Notiser 114.
- BJÖRNSSON, S. 1936. Ett västblekingskt platålandskap. — Svensk geogr. Årsb. 12.
- 1946. Blekinge. En studie av det blekingska kulturlandskapet. — Meddn Lunds geogr. Instn 9.
- BLOMGREN, N. & NAUMANN, E. 1925. Untersuchungen über die höhere Vegetation des Sees Stråken bei Aneboda. — Acta Univ. lund. 2, 21: 6.
- BLUM, G. 1958. Osmotischer Wert, Saugkraft, Turgor. — Protoplasmatologia 2: C7a.
- BROWN, I. C. 1943. A rapid method of determining exchangeable hydrogen and total exchangeable bases of soils. — Soil Sci. 56.
- BROYER, T. C. & HOAGLAND, D. R. 1940. Methods of sap expression from plant tissues with special reference to studies on salt accumulation by excised barley roots. — Am. J. Bot. 27.
- BRUNDIN, L. 1949. Chironomiden und andere Bodentiere der sydschwedischen Urgebirgseen. Ein Beitrag zur Kenntnis der bodenfaunistischen Charakterzüge schwedischer oligotropher Seen. (With English summary.) — Rep. Inst. Freshwat. Res. Drottningholm 30.
- BURSTRÖM, H. 1942. Die osmotischen Verhältnisse während des Streckungswachstums der Wurzel. — Lantbr-Högsk. Annlr 10.
- CAIN, S. A. & CAIN, L. G. 1944. Size-frequency studies of Pinus palustris pollen. — Ecology 25.
- 1948. Size-frequency characteristics of Pinus echinata pollen. — Bot. Gaz. 110.
- CAINES, L. A. 1965. The phosphorus content of some aquatic macrophytes with special reference to seasonal fluctuations and applications of phosphate fertilizers. — Hydrobiologia 25.
- CARLIN, B. 1939. Über die Rotatorien einiger Seen bei Aneboda. — Meddn Lunds Univ. limnol. Instn 2.
- CHAPMAN, V. J. 1960. Salt marshes and salt deserts of the world. — Plant Science Monographs. London.

- CHRISTENSEN, B. BRORSON. 1946. Measurement as a means of identifying fossil pollen. — Danm. geol. Unders. 4: 3.
- CRONHOLM, M. 1946. Über die Hydracarinien der Aneboda-Seen. — Meddn Lunds Univ. limnol. Instn 6.
- DAHLBECK, N. 1945. Strandwiesen am südöstlichen Öresund. — Acta phytogeogr. suec. 18.
- Danmarks Klima. 1933. — Ed. Det danske meteorologiske Institut. København.
- Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlamm-Untersuchung. Physikalische, chemische und bakteriologische Verfahren. — 3rd edition.
- DIGERFELDT, G. 1966. A new type of large-capacity sampler. — Geol. Förs. Stockh. Förs. 87.
- DU RIETZ, G. E. 1930. Algbälten och vattenståndsväxlingar vid svenska östersjökusten. — Bot. Notiser 83.
- DU RIETZ, G. E. & GRETA. 1925. Floristiska anteckningar från Blekinge skärgård. — Bot. Notiser 78.
- DU RIETZ, G. E., HANNERZ, A. G., LOHAMMAR, G., SANTESSON, R. & WAERN, M. 1939. Zur Kenntnis der Vegetation des Sees Tåkern. — Acta phytogeogr. suec. 12.
- ENEROTH, O. 1951. Undersökning rörande möjligheterna att i fossilt material urskilja de olika *Betula*-arternas pollen. — Geol. Förs. Stockh. Förs. 73.
- ERDTMAN, G. 1936. New methods in pollen analysis. — Svensk bot. Tidskr. 30.
- 1943. An introduction to pollen analysis. — New Ser. Plant Sci. Books 12.
- 1952. Pollen morphology and plant taxonomy. Angiosperms. — Stockholm.
- ERDTMAN, G. & NORDBORG, G. 1961. Über Möglichkeiten die Geschichte verschiedener Chromosomenzahlenrassen von *Sanguisorba officinalis* und *S. minor* pollenanalytisch zu beleuchten. — Bot. Notiser 114.
- ERNST, A. 1953. Die Relation Antherenstellung/Pollenkorngröße bei Blütendimorphismus und das Kompatibilitätsproblem. — Planta 42.
- FAEGRI, K. 1940. Quartärgeologische Untersuchungen im westlichen Norwegen. II. Zur spätquartären Geschichte Jaerens. — Bergens Mus. Årb. 7.
- FIRBAS, F. 1937. Der pollenanalytische Nachweis des Getreidebaus. — Z. Bot. 31.
- FLORIN, M.-B. 1957. Plankton of fresh and brackish waters in the Södertälje area. — Acta phytogeogr. suec. 37.
- FORSBERG, C. 1964 a. The vegetation changes in Lake Tåkern. — Svensk bot. Tidskr. 58.
- 1964 b. Phosphorus, a maximum factor in the growth of Characeae. — Nature 201.
- GEISLER, F. 1945. A study of pollen grains of thirty-two species of grasses. — Butler Univ. bot. Stud. 7.
- GESSNER, F. 1959. Hydrobotanik. Die physiologischen Grundlagen der Pflanzenverbreitung im Wasser. II. Stoffhaushalt. — Berlin.
- GILLNER, V. 1960. Vegetations- und Standortuntersuchungen in den Strandwiesen der schwedischen Westküste. — Acta phytogeogr. suec. 43.
- 1965. Salt marsh vegetation in southern Sweden. — Acta phytogeogr. suec. 50.
- GORHAM, E. & PEARSALL, W. H. 1956. Production ecology. III. Shoot production in *Phragmites* in relation to habitat. — Oikos 7.
- GUSTAFSSON, Å. 1948. Polyploidy, life-form and vegetative reproduction. — Hereditas 34.
- GUSTAFSSON, Å. & SIMAK, M. 1963. X-ray photography and seed sterility in *Phragmites communis* Trin. — Hereditas 49.
- GYÖRFFY, B. 1941. Untersuchungen über den osmotischen Wert polyploider Pflanzen. — Planta 32.
- HAGERUP, O. 1941. Nordiske kromosom-tal. I. — Bot. Tidskr. 45.
- HANSEN, K. 1944. Investigations of the geography and natural history of the Praestø Fjord, Zealand. I. Introduction and the bottom deposits. — Folia geogr. dan. 3: 1.
- 1950. The geology and bottom deposits of lake Tystrup Sø, Zealand. — Danm. geol. Unders. 2: 76.
- 1962. The dystrophic lake type. — Hydrobiologia 19.
- HAYES, F. R., REID, B. L. & CAMERON, M. L. 1958. Lake water and sediment. II. Oxidation-reduction relations at the mud-water interface. — Limnol. Oceanogr. 3.
- HILDING, S. 1948. Om tidvattnet å Västskusten. — Svensk geogr. Årsb. 24.
- HUNTER, A. W. S. 1934. A karyosystematic investigation in the Gramineae. — Can. J. Res. 11.
- HÜRLIMANN, H. 1951. Zur Lebensgeschichte des Schilfs an den Ufern der Schweizer Seen. — Beitr. geobot. Landesaufn. Schweiz 30.

- HYLANDER, N. 1955. Förteckning över Nordens växter. I. Kärlväxter. [List of the plants of N.W. Europe (Sweden, Norway, Denmark, East Fennoscandia, Iceland and the Faeroes). I. Vascular plants.] — Lund.
- JENSEN, A. J. C. 1944. The Hydrography of Praestø Fjord. — *Folia geogr. dan.* 3: 2.
- JONES, M. D. & NEWELL, L. C. 1948. Size, variability, and identification of grass pollen. — *J. Am. Soc. Agron.* 40.
- KAIKKO, J. 1934. Über die Grössenverhältnisse des Rhizoms und des Sprosses bei *Phragmites communis* auf verschiedenen Wassertiefen. — *Suomal. eläin-ja kasvit. Seur. van. kasvit. Julk.* 5: 10.
- KARLGREN, L. 1961. Vattenkemiska analysmetoder. — Mimeographed. Institute of Limnology, Uppsala.
- KIENDL, J. 1953. Zum Wasserhaushalt des *Phragmitetum communis* und des *Glycerietum aquaticae*. — *Ber. dt. bot. Ges.* 66.
- KNUTSON, K. 1949. Jordprovens kemiska och mekaniska analys. Appendix 2 in MALMSTRÖM Studier över skogstyper och trädslagsfördelning inom Västerbottens län. — *Meddn. St. SkogsforsknInst.* 37.
- KRAUSCH, H. D. 1956. Das Riesenrohr im Kreise Luckau und sein Schutz. — *Märkische Heimat.*
- KRISTIANSEN, J. & MATHIESEN, H. 1964. Phytoplankton of the Tystrup-Bavelse Lakes. Primary production and standing crop. — *Oikos* 15.
- KURIMOTO, T., TAKADA, H. & NAGAI, S. 1954. Physiology of *Metasequoia glyptostroboides* and related species of conifers. I. Osmotic value and salt composition of leaf saps. — *J. Inst. Polytech. Osaka Cy Univ.* D: 5.
- LANDOLT-BÖRNSTEIN. 1962. Zahlenwerte und Funktionen aus Physik, Chemie, Astronomie, Geophysik und Technik. — 6th edition. 2: 2a.
- LANG, K. 1931. Faunistisch-ökologische Untersuchungen in einigen seichten oligotrophen bzw. dystrophen Seen in Südschweden. — *Acta Univ. lund.* 2, 27: 18.
- LANGLET, O. 1939. Ett bidrag till kännedomen om tallpollens modifierbarhet. — *Norrlands SkogsvFörb. Tidskr. Stockh.*
- LARSSON, D. 1934. Vesans invallningsföretag. — *Svenska MosskultFör. Tidskr.* 48.
- LARSSON, I. 1954. Structure and landscape in western Blekinge. — Lund.
- LEHTORANTA, L. 1956. Über den Kationen- und Chlorgehalt des Zellsaftes, insbesondere bei Submersen. — *Suomal. eläin-ja kasvit. Seur. van. kasvit. Julk.* 29: 1.
- LEOPOLD, E. B. 1956. Pollen size-frequency in New England species of the genus *Betula*. — *Grana palynol.* 1: 2.
- LEVITT, J. 1951 a. Toward a clearer concept of osmotic quantities in plant cells. — *Science* 113.
- 1951 b. The osmotic equivalent and osmotic potential difference of plant cells. — *Physiologia Pl.* 4.
- LEXANDER, K. 1963. Relations between earliness of spring wheat varieties and some properties in connexion with their germination and seedling growth. — *Physiologia Pl. Suppl.* 2.
- LILLIEROTH, S. 1950. Über Folgen kulturbedingter Wasserstandsenerkungen für Makrophyten- und Planktongemeinschaften in seichten Seen des südschwedischen Oligotrophiegebietes. Eine Studie mit besonderer Berücksichtigung der angewandten Limnologie. — *Acta limnol.* 3.
- LINKOLA, K. 1916. Studien über den Einfluss der Kultur auf die Flora in den Gegenden nördlich vom Ladogasee. I. Allgemeiner Teil. — *Acta Soc. Fauna Flora fenn.* 45.
- LOHAMMAR, G. 1931. Two chromosome numbers in *Butomus umbellatus* L. — *Svensk bot. Tidskr.* 25.
- 1938. Wasserchemie und höhere Vegetation schwedischer Seen. — *Symb. bot. upsäl.* 3: 1.
- 1965 a. The vegetation of Swedish lakes. — *Acta phytogeogr. suec.* 50.
- 1965 b. Some observations on horizontal variations in an eutrophic lake. — Paper read at XVI Limnol. Convent., Warszawa. [Proc. int. Ass. theor. appl. Limnol. 16. (In press.)]
- LÖVE, A. 1954. Cytotaxonomical evaluation of corresponding taxa. — *Vegetatio* 5—6.
- LÖVE, A. & LÖVE, D. 1961. Chromosome numbers of central and northwest European plant species. — *Op. bot. Soc. bot. Lund* 5.
- LÖVKVIST, B. 1956. The *Cardamine pratensis* complex. Outlines of its cytogenetics and taxonomy. — *Symb. bot. upsäl.* 14: 2.
- LUNDEGÅRDH, P. H., LUNDQVIST, J. & LINDSTRÖM, M. 1964. Berg och jord i Sverige. — Stockholm.
- LUNDÉN, M. 1795. Afhandling om wassen *Arundo phragmites* Linn. — Åbo.
- LUNDH, A. 1951 a. Some aspects of the higher aquatic vegetation in the lake Ringsjön in Scania. — *Bot. Notiser* 104.
- 1951 b. Studies on the vegetation and hydro-

- chemistry of Scanian lakes. I. Higher aquatic vegetation. — *Bot. Notiser*. Suppl. 2: 3.
- 1951 c. Studies on the vegetation and hydrochemistry of Scanian lakes. III. Distribution of macrophytes and some algal groups. — *Bot. Notiser*. Suppl. 3: 1.
- LUNDQVIST, G. 1925. Utvecklingshistoriska insjöstudier i Sydsverige. (With German summary.) — *Sver. geol. Unders. Afh.* C 330.
- LUTHER, H. 1950 a. Beobachtungen über die fruktifikative Vermehrung von *Phragmites communis* Trin. — *Acta bot. fenn.* 46.
- 1950 b. Traditionen om det felsläende vassfröet. — *Nya Argus* 43.
- 1951. Verbreitung und Ökologie der höheren Wasserpflanzen im Brackwasser der Ekenäs-Gegend in Südfinnland. II. Spezieller Teil. — *Acta bot. fenn.* 50.
- MALMER, N. 1958. Notes on the relation between the chemical composition of mire plants and peat. — *Bot. Notiser* 111.
- 1960. Some ecologic studies on lakes and brooks in the south Swedish uplands. — *Bot. Notiser* 113.
- 1961. Ecologic studies on the water chemistry of lakes in South Sweden. — *Bot. Notiser* 114.
- 1962 a. Studies on mire vegetation in the Archaean area of southwestern Götaland (South Sweden). I. Vegetation and habitat conditions on the Åkhult mire. — *Op. bot. Soc. bot. Lund* 7: 1.
- 1962 b. Studies on mire vegetation in the Archaean area of southwestern Götaland (South Sweden). II. Distribution and seasonal variation in elementary constituents on some mire sites. — *Op. bot. Soc. bot. Lund* 7: 2.
- MALMER, N. & SJÖRS, H. 1955. Some determinations of elementary constituents in mire plants and peat. — *Bot. Notiser* 108.
- MATHIESEN, H. 1966. Om planteplanktonets brutoproduktion og bundvegetationens forekomst i nogle danske søer (Midtjylland). — *Vattenhygien* 22.
- MAUCHA, R. 1932. Hydrochemische Methoden in der Limnologie mit besonderer Berücksichtigung der Verfahren von L. W. Winkler. — *Binnengewässer* 12.
- MAURIZIO, A. 1956. Pollengestaltung bei einigen polyploiden Kulturpflanzen. — *Grana palynol.* 1: 2.
- MELIN, R. 1928. Tåkern, en hydrografisk undersökning. (With French summary.) — *Meddn St. met.-hydrogr. Anst.* 4: 10.
- METCALFE, C. R. 1960. Anatomy of the Monocotyledons. I. Gramineae. — Oxford.
- METSÄVAINIO, K. 1931. Untersuchungen über das Wurzelsystem der Moorpflanzen. — *Suomal. eläin-ja kasvit. Seur. van. kasvit. Julk.* 1: 1.
- MIKKELSEN, V. M. 1948. Et forsøg til identificering af cruciferpollen i honning. — *Tidsskr. Plavl* 51.
- 1949. Has temperature any influence on pollen size? — *Physiologia Pl.* 2.
- MISRA, R. D. 1938. Edaphic factors in the distribution of aquatic plants in the English lakes. — *J. Ecol.* 26.
- MORTIMER, C. H. 1942. The exchange of dissolved substances between mud and water in lakes. — *J. Ecol.* 30.
- MÜLLER-STOLL, W. R. 1938. Wasserhaushaltsfragen bei Sump- und emersen Wasserpflanzen. — *Ber. dt. bot. Ges.* 56.
- MÜNTZING, A. 1927. Chromosome number, nuclear volume and pollen grain size in *Galeopsis*. — *Hereditas* 10.
- NAUMANN, E. 1917. Undersökningar öfver fytoplankton och under den pelagiska regionen försiggående gyttje- och dybildningar inom vissa syd- och mellansvenska urbergsvatten. (With German summary.) — *K. svenska Vetensk.-Akad. Handl.* 56: 6.
- 1922. Södra och mellersta Sveriges sjö- och myrmarker. Deras bildningshistoria, utbredning och praktiska betydelse. (With German summary.) — *Sver. geol. Unders. Afh.* C 297.
- 1923. Einige Grundzüge der regionalen Limnologie Süd- und Mittelschwedens. — *Proc. int. Ass. theor. appl. Limnol.* 1.
- 1932. Grundzüge der regionalen Limnologie. — *Binnengewässer* 11.
- NAVALKAR, B. S. 1940. Studies in the ecology of mangroves. 1. Determination of osmotic pressure of *Avicennia alba*, Blume. — *J. Univ. Bombay* 8: 5.
- NORIN, R. 1936. Contributions to the geology of western Blekinge. — *Geol. För. Stockh. Förh.* 58.
- OHLE, W. 1964. Interstitiallösungen der Sedimente, Nährstoffgehalt des Wassers und Primärproduktion des Phytoplanktons in Seen. — *Helgoländer wiss. Meeresunters.* 10.
- 1965. Interstitiallösungen der Sedimente in Beziehung zum limnischen Stoffhaushalt. — Paper read at XVI Limnol. Convent., Warszawa. [*Proc. int. Ass. theor. appl. Limnol.* 16. (In press.)]

- OLSEN, C. 1948. The mineral, nitrogen and sugar content of beech leaves and beech leaf sap at various times. — C. r. Trav. Lab. Carlsberg 26: 5.
- OLSEN, S. 1945. The vegetation in Praestø Fjord. 1. Spermatophyta and Charophyta. — Folia geogr. dan. 3: 4.
- OPPENHEIMER, H. R. 1932. Über Zuverlässigkeit und Anwendungsgrenzen der üblichsten Methoden zur Bestimmung der osmotischen Konzentration pflanzlicher Zellsäfte. — Planta 16.
- OVERBEEK, J. van. 1956. Absorption and translocation of plant regulators. — A. Rev. Pl. Physiol. 7.
- OVTCHINNIKOV, N. N. 1951. Regularities in the dimensional variation of pollen. (In Russian.) — Dokl. Akad. Nauk SSSR 77: 4.
- OVTCHINNIKOV, N. N. & SCHICHANOVA, N. M. 1953. On the pollen variability in different parts of the inflorescences in rye. (In Russian.) — Dokl. Akad. Nauk SSSR 88: 5.
- PACLT, J. 1958. Farbenbestimmung in der Biologie. — Jena.
- PALLIS, M. 1916. The structure and history of plav: the floating fen of the delta of the Danube. — J. Linn. Soc. Botany 43.
- PERSSON, Å. 1962. Mire and spring vegetation in an area north of Lake Torneträsk, Torne Lappmark, Sweden. II. Habitat conditions. — Op. bot. Soc. bot. Lund 6: 3.
- 1964. The vegetation at the margin of the receding glacier Skaftafellsjökull, southeastern Iceland. — Bot. Notiser 117.
- PISEK, A. & TRANQUILLINI, W. 1951. Transpiration und Wasserhaushalt der Fichte (*Picea excelsa*) bei zunehmender Luft- und Bodentrockenheit. — Physiologia Pl. 4.
- PROCTOR, C. M. & HOOD, D. W. 1954. Determination of inorganic phosphate in sea water by an iso-butanol extraction procedure. — J. mar. Res. 13.
- RAMANATHAN, K. 1950. Addendum to list of chromosome numbers in economic plants. — Curr. Sci. 19.
- REESE, G. 1957. Über die Polyploidiespektren in der nordsaharischen Wüstenflora. — Flora, Jena 144.
- RODEWALD, L. 1943. Das Schilfproblem in Rumänien mit besonderer Berücksichtigung des Donaodeltas, im Lichte der Fischwirtschaft und Jagd dieses Landes und seine Beziehung zur Wirtschaft Mitteleuropas. — Anal. Inst. Cerc. pisc. Rom 2.
- RODHE, W. 1941. Zur Verbesserung der quantitativen Planktonmethodik nebst Profilen des Crustaceenplanktons aus drei småländischen Seen. — Zool. Bidr. Upps. 20.
- RODHE, W., LINDGREN, Ö. & TULLANDER, V. 1962. Investigations of swan localities in Blekinge (Sweden). Chemical and bacteriological studies. — Mimeographed. Institute of Limnology, Uppsala.
- RUDESCU, L. 1965. Neue biologische Probleme bei den Phragmiteskulturarbeiten im Donaudelta. — Arch. Hydrobiol. Suppl. 30.
- RUDESCU, L., NICULESCU, C. & CHIVU, I. P. 1965. Monografia stufului din Delta Dunării. — București.
- RUTTNER, F. 1963. Fundamentals of limnology. — Toronto.
- SAMUELSSON, G. 1925. Untersuchungen über die höhere Wasserflora von Dalarne. — Svenska växtsoc. Sällsk. Handl. 9.
- SANTESSON, R. 1939. Über die Zonationsverhältnisse der lakustrinen Flechten einiger Seen im Anebodgebiet. — Meddn Lunds Univ. limnol. Instn 1.
- SAURA, F. 1948. Cariologia de Gramineas en Argentina. — Revta Fac. Agron. Vet. Univ. B. Aires 12.
- SCHOCH-BODMER, H. 1936. Zur Methodik der Grössenbestimmung von Pollenkörnern, mit besonderer Berücksichtigung von *Corylus avellana*. — Ber. schweiz. bot. Ges. 45.
- 1938. Die Veränderlichkeit der Pollengrösse bei *Lythrum salicaria*. — Flora, Jena 33.
- 1940. The influence of nutrition upon pollen grain size in *Lythrum salicaria*. — J. Genet. 40.
- SCHWANITZ, F. 1950. Untersuchungen an polyploiden Pflanzen. VI. Pollengrösse und Zellkerngrösse bei diploiden und autotetraploiden Pflanzen. — Züchter 20.
- 1952. Einige kritische Bemerkungen zur Methode der Bestimmung der Polyploidie durch Messung der Pollen- und Spaltöffnungsgrösse. — Züchter 22.
- SEGERSTRÅLE, S. G. 1951. The seasonal fluctuations in the salinity off the coast of Finland and their biological significance. — Commentat. biol. 13: 3.
- 1957. Baltic Sea. — Mem. geol. Soc. Am. 67. (Reprinted 1963.)

- 1965. On the salinity conditions off the south coast of Finland since 1950, with comments on some remarkable hydrographical and biological phenomena in the Baltic area during this period. — *Commentat. biol.* 28: 7.
- SEIDEL, K. 1955. Die Flechtbinse, *Scirpus lacustris* L. Ökologie, Morphologie und Entwicklung, ihre Stellung bei den Völkern und ihre wirtschaftliche Bedeutung. — *Binnengewässer* 21.
- SELANDER, S. 1955. Det levande landskapet i Sverige. — Stockholm.
- SERNANDER, R. 1912. Studier öfver lafvarnes biologi. I. Nitrofila lafvar. — *Svensk bot. Tidskr.* 6.
- SJÖBORG, N. H. 1792. Utkast till Blekinges historia och beskrifning. — Lund.
- Sjön Tåkerns fauna och flora. 1929. (Published by the Royal Swedish Academy of Sciences.) — Uppsala.
- SJÖRS, H. 1946. Myrvegetationen inom övre Långanområdet i Jämtland. — *Ark. Bot.* 33 A.
- 1952. On the relation between vegetation and electrolytes in north Swedish mire waters. — *Oikos* 2.
- 1954. Slätterängar i Grangärde Finnmark. — *Acta phytogeogr. suec.* 34.
- 1961. Some chemical properties of the humus layer in Swedish natural soils. — *K. Skogshögsk. Skr.* 37.
- 1965. Features of land and climate. — *Acta phytogeogr. suec.* 50.
- Skrivregler. 1964. — *Tek. NomenklCent. Publ* 37.
- STÅLFELT, M. G. 1960. Växtekologi. Balansen mellan växtvärldens produktion och beskattning. — Stockholm.
- STANT, M. Y. 1953. Variations in reed structure in relation to thatching. — *Kew Bull.*
- STARK, P. 1927. Über die Zugehörigkeit des Kieferpollens in den verschiedenen Horizonten der Bodenseemoore. — *Ber. dt. bot. Ges.* 45.
- STEINER, M. 1933. Zum Chemismus der osmotischen Jahresschwankungen einiger immergrüner Holzgewächse. — *Jb. wiss. Bot.* 78.
- 1934. Zur Ökologie der Salzmarschen der nordöstlichen Vereinigten Staaten von Nordamerika. (Die osmotischen Verhältnisse des Bodens als Standortsfaktor. Die Ökologie der osmotischen Werte und der Zellsaftchemie bei Halophyten.) — *Jb. wiss. Bot.* 81.
- 1939. Die Zusammensetzung des Zellsaftes bei höheren Pflanzen in ihrer ökologischen Bedeutung. — *Ergeb. Biol.* 17.
- STODDART, L. A. 1935. Osmotic pressure and water content of prairie plants. — *Pl. Physiol.*, Lancaster 10.
- STOY, V. 1965. Photosynthesis, respiration, and carbohydrate accumulation in spring wheat in relation to yield. — *Physiologia Pl. Suppl.* 4.
- STRANDHEDE, S.-O. 1966. Morphologic variation and taxonomy in European *Eleocharis*, subser. *Palustres*. — *Op. bot. Soc. bot. Lund* 10: 2.
- SUTCLIFFE, J. F. 1962. Mineral salts absorption in plants. — *Int. ser. of monographs on pure and applied biology. Plant physiology div. 1.* Pergamon Press.
- Style manual for biological journals. 1961. — Washington.
- TAKADA, H. 1950. Untersuchungen über den osmotischen Wert von einigen Strandpflanzen in Japan. — *J. Inst. Polytech. Osaka Cy Univ. D:* 1.
- 1951. Über Tagesschwankung des osmotischen Wertes in den Blättern von Strandpflanzen in ihrem Zusammenhange mit dem Chloridgehalt. — *J. Inst. Polytech. Osaka Cy Univ. D:* 2.
- 1954. Ion accumulation and osmotic value of plants, with special reference to strand plants. — *J. Inst. Polytech. Osaka Cy Univ. D:* 5.
- TAKADA, H. & NAGAI, S. 1953. Notes on the rich chloride content and the osmotic pressure of *Metasequoia glyptostroboides*. — *Proc. Japan Acad.* 29.
- TAMM, C. O. 1951. Seasonal variation in composition of birch leaves. — *Physiologia Pl.* 4.
- 1954. Growth, yield and nutrition in carpets of a forest moss (*Hylocomium splendens*). — *Meddn St. SkogsforskInst.* 43.
- TARNAVSCHI, I. T. 1948. Die Chromosomenzahlen der Anthophyten-Flora von Rumänien mit einem Ausblick auf das Polyploidie-Problem. — *Bul. Grăd. bot. Muz. bot. Univ. Cluj* 28.
- THOMASSON, K. 1955. Om den biocönotiska dynamiken i grunda sjöar. Några synpunkter på Tåkerns oroväckande utveckling. — *Sver. Nat.*
- THREN, R. 1934. Jahreszeitliche Schwankungen des osmotischen Wertes verschiedener ökologischer Typen in der Umgebung von Heidelberg.

- berg, Mit einem Beitrag zur Methodik der Presssaftuntersuchung. — Z. Bot. 26.
- THUNMARK, S. 1931. Der See Fiolen und seine Vegetation. — Acta phytogeogr. suec. 2.
- 1937. Über die regionale Limnologie von Südschweden. — Sver. geol. Unders. Afh. C 410.
- 1942. Über rezente Eisenocker und ihre Mikroorganismengemeinschaften. — Bull. geol. Instn Univ. Upsala 29.
- 1945 a. Die Abwasserfrage der Väckjö-Seen in hydrobiologischer Beleuchtung. Grundzüge in der regionalen Planktologie von Südschweden. — Meddn Lunds Univ. limnol. Instn 4.
- 1945 b. Zur Soziologie des Süßwasserplanktons. Eine methodologisch-ökologische Studie. — Folia limnol. scand. 3.
- 1948. Sjöar och myrar i Lenhovda socken. — Lenhovda. En värendssocken berättar. Moheda.
- 1952. Karaktärsdrag i sömländsk sjövegetation. — Natur i Södermanland. Göteborg.
- TISCHLER, G. 1918. Untersuchungen über den Riesenwuchs von *Phragmites communis* var. *Pseudodonax*. — Ber. dt. bot. Ges. 36.
- 1929. Revisionen früherer Chromosomenzählungen und anschliessende Untersuchungen. — Planta 8.
- 1942. Polyploidie und Artbildung. — Naturwissenschaften 30.
- TISCHLER, G. & WULFF, H. D. 1963. Allgemeine Pflanzenkaryologie. Angewandte Pflanzenkaryologie. — Handb. PflAnat. 2:2.
- TOBLER, F. 1943. Stengelbau, Festigkeits- und Verwertungsunterschiede beim Schilfrohr (*Phragmites communis* Trin.). — Angew. Bot. 25.
- TROELS-SMITH, J. 1955. Karakterisering af løse jordarter. Characterization of unconsolidated sediments. — Danm. geol. Unders. 4:3.
- TRYBOM, F. 1893. Ringsjön i Malmöhus län, dess naturförhållanden och fiske. — Meddn K. LantbrStyr. 4.
- WAGENITZ, G. 1955. Über die Änderung der Pollengrösse von Getreiden durch verschiedene Ernährungsbedingungen. — Ber. dt. bot. Ges. 68.
- WALTER, H. 1928. Über die Presssaftgewinnung für kryoskopische Messungen des osmotischen Wertes bei Pflanzen. — Ber. dt. bot. Ges. 46.
- 1931 a. Die kryoskopische Bestimmung des osmotischen Wertes bei Pflanzen. — Handb. biol. ArbMeth. 11:4.
- 1931 b. Die Hydratur der Pflanze und ihre physiologisch-ökologische Bedeutung. (Untersuchungen über den osmotischen Wert.) — Jena.
- 1936. Tabellen zur Berechnung des osmotischen Wertes von Pflanzenpresssäften, Zuckerlösungen und einigen Salzlösungen. — Ber. dt. bot. Ges. 54.
- 1951. Einführung in die Phytologie. III. Grundlagen der Pflanzenverbreitung. I. Teil: Standortslehre (analytisch-ökologische Geobotanik). — Stuttgart.
- WALTER, H. & WALTER, E. 1929. Ökologische Untersuchungen des osmotischen Wertes bei Pflanzen aus der Umgebung des Balatons (Plattensees) in Ungarn während der Dürrezeit 1928. — Planta 8.
- WENNBERG, G. 1949. Differentialrörelser i inlandsisen. Sista istiden i Danmark, Skåne och Östersjön. — Meddn Lunds geol.-miner. Instn 114.
- WENNER, C.-G. 1948. Pollen diagrams from Labrador. A contribution to the Quaternary geology of Newfoundland-Labrador, with comparisons between North America and Europe. — Geogr. Annlr
- WESTLAKE, D. F. 1963. Comparisons of plant productivity. — Biol. Rev. 38:3.
- WETZEL, R. G. 1964. Primary productivity of aquatic macrophytes. — Proc. int. Ass. theor. appl. Limnol. 15.
- WILLER, A. 1949. Kleinklimatische Untersuchungen im Phragmites-Gelege. — Proc. int. Ass. theor. appl. Limnol. 10.
- 1950. Biologie und Kleinklima im Rohrgelege. — Arch. FischWiss. 2.
- ZINZADZE, CH. 1935. Colorimetric methods for the determination of phosphorus in the presence of silica, arsenic, iron and nitrates. — Ind. EngngChem. analyt. Edn 7:4.

FOLIA LIMNOLOGICA SCANDINAVICA

edited by

KAJ BERG (University of Copenhagen, Denmark), SVEN BJÖRK (University of Lund, Sweden),
REINO RYHÄNEN (University of Helsinki, Finland).

- No. 1. KAJ BERG: Physiographical Studies on the River Susaa. 1943. Price 10 dol. (Reprinted by Johnson Reprint Corporation, New York).
- No. 2. S. A. BOISEN BENNIKE: Contributions to the Ecology and Biology of the Danish Fresh-water Leeches (Hirudinea). 1943. Price 10 dol. (Reprinted by Johnson Reprint Corporation, New York).
- No. 3. SVEN THUNMARK: Zur Soziologie des Süßwasserplanktons. Eine methodologisch-ökologische Studie. 1945. Price 12 Sw. Kr.
- No. 4. KAJ BERG: Biological Studies on the River Susaa. (With Contributions by S. A. BOISEN BENNIKE †, PÉTUR M. JÓNASSON, JOHS. KEIDING, and ANKER NIELSEN.). 1948. Will be reprinted 1968.
- No. 5. E. FJERDINGSTAD: The Microflora of the River Mølleaa. With Special Reference to the Relation of the Benthic Algæ to Pollution. 1950. Price 23 Danish Kr.
- No. 6. NIELS FOGED: On the Diatom Flora of Some Funen Lakes. 1954. Price 26 Danish Kr.
- No. 7. SIGURD OLSEN: Lake Lyngby Sø. Limnological Studies on a Culturally Influenced Lake. General Description and the Ecological Conditions of the Water and the Bottom Deposits. 1955. Price 38 Danish Kr.
- No. 8. KAJ BERG and IB CLEMENS PETERSEN: Studies on the Humic, Acid Lake Gribsø. (With Contributions by KAJ HANSEN, PER WOLTERS, and GUNNAR NYGAARD). 1956. Price 69 Danish Kr.
- No. 9. HALVOR VEGARD HAUGE: Vangsvatn and Some Other Lakes near Voss. A Limnological Survey in Western Norway. 1957. Price 20 Norw. Kr.
- No. 10. KAJ BERG et al: Furesøundersøgelser 1950—54. Limnologiske studier over Furesø's kulturpåvirkning. (English Summary: Investigations on Fure Lake 1950—54. Limnological studies on cultural influences.) 1958. Price 45 Danish Kr.
- No. 11. KÅRE ELGMØRK: Seasonal Occurrence of Cyclops strenuus strenuus in Relation to Environment in Small Water Bodies in Southern Norway. 1959. Price 30 Norw. Kr.
- No. 12. KÅRE ELGMØRK: Dynamics of Zooplankton Communities in some Small Inundated Ponds. 1964. Price 25 Norw. Kr.
- No. 13. JAN ÖKLAND: The eutrophic lake Borrevann (Norway) — an ecological study on shore and bottom fauna with special reference to gastropods, including a hydrographic survey. 1964. Price 45 Norw. Kr.
- No. 14. SVEN BJÖRK: Ecologic Investigations of Phragmites communis. Studies in Theoretic and Applied Limnology. 1967. Price 55 Sw. Kr.

The *Folia Limnologica Scandinavica* will be published at irregular intervals.